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Creating Project-Based Math Curricula: A Narrative Inquiry

A Dissertation

Presented to the Faculty of the  
College of Education and Social Work  
West Chester University  
West Chester, Pennsylvania

In Partial Fulfillment of the Requirements for  
the Degree of  
Doctor of Education

By

Marcie T. Hull

May 2020

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## Dedication

I dedicate this work to my participants. Although I cannot mention you by name here, you know who you are and what this work means. It is an honor to tell your stories. Thank you for your time and for your trust. You are the educators that have poured your hearts and souls into your craft and have contributed to the field of Education. This is dedicated to all those teachers, especially those who are kind and care for their pupils. It is because of all of you my career and this dissertation are possible.

## Acknowledgements

I am and have been consistently humbled by the support and encouragement I have received throughout this endeavor, one that I embarked upon three long years ago. Mainly, I have my professors, the faculty at West Chester University, and my cohort to thank for this life-changing experience. Thank you to my professors: Dr. Haworth, Dr. Morgan Dr. Norris, Dr. Schugar, Dr. Staulters, Dr. Kruger-Ross, Dr. Bolton, Dr. McLaughlin, Dr. Backer, and Dr. Zalewski. Thank you to my cohort members: Amy Jenkins, Jane Ferris, Jenn Smerecky, Jeff Mapes, Lisa Dimaio, Lisa Montgomery, Maria Lepore-Stevens and, Mike Garvin.

My professional life has brought me into the proximity of intensely smart and talented educators, most of whom have become my friends. I am grateful for their influence, advice, and patience as I traveled the path to becoming a Doctor. This includes all the people who worked for and are presently employed at the Science Leadership Academies, and each of the schools where I was fortunate to consult: YSC Academy, Hampton High School, as well as various School District of Philadelphia schools. Thank you to Inquiry Schools and The Philadelphia Learning Collaborative for the opportunity to learn and grow with you, your members, and your networks. Also, thank you to my ISTE peeps, the blogosphere and the educational technology geniuses that have talked with me, mentored me, and put up with me. And thank you, Chris Lehmann, for creating these incredible schools, without which, none of this would be possible.

I wish I had the words for my family and friends. Those closest to me know I always ask for words because they consistently escape my nervous brain. Anything I put down here could not convey the love I have for you. Thank you for being in my life and for seeing me through this process. Chase and Steven, you are the loves of my life and without your love,

laughter, and support, I would never have reached this goal, this achievement is as much yours as it is mine. I am grateful and so in love. Steven, you're so cool.

Finishing this was a push that could only be done two Trappist Rocheforts at a time, served up by my faithful grocery store cashier, Andrea, Thank you Andrea! Those delicious beers in combination with the bands Tool and Deftones got this woman to the finish line.

## Abstract

This study is a narrative inquiry about the participant's experiences, in three individual case studies, involving teachers of high school mathematics engaged in the creation of a project-based learning curriculum, in a one-to-one laptop school. The researcher analyzed data from field notes, digital artifacts, and teacher interviews to document how math teachers are creating curriculum in an inquiry-driven, project-based, technology-infused instructional model. Findings from restorying and the analysis of three-dimensional space —regarding teacher lore —reveal themes about math teacher curriculum conflicts in skill-building, application of iterative design thinking, and structures inherent to project-based learning. Rich, thick description of the cases, in narrative form, synthesizes a segment in time that results in knowledge and understandings that call future researchers to investigate iterative design theory as it relates to the creation of a mathematics project-based learning curriculum.

Keywords: narrative case study, project-based learning, mathematics, curriculum, teacher experience, constructivism, experiential learning theory, three-dimensional space, teacher lore, iterative design

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## Chapter 1: Introduction

“Who is this?” Mr. Brown asks.

Ms. Garcia replies, “I don’t know. Google him.”

Mr. Bell chimes in, “I already did. They seem to be a company out of New Jersey and this person is not listed on their website.” His closing shrug emoji draws smiles from the others.

“Wait, I found him,” types Ms. Parks, who then pastes in the presenter’s LinkedIn profile page and states, “He just started working there, SMH (shaking my head).”

This is the way three “back-channeling” teachers and one principal started the district’s mandatory professional development session on interdisciplinary teaching with project-based learning strategies.

“We should be excused from this,” Ms. Garcia types as she refrains from using all caps.

“More like we should be leading this,” explains Principal Bell. “I don’t know why they don’t ever consult us about these professional developments,” he laments. “The three of you have so much more to offer the teachers in our community than this consultant ever will.”

Ms. Parks asks, “Why don’t they understand that the project-based model has all this kind of stuff embedded in it?”

Ms. Garcia bangs on her computer keys as she types. “Well, I am using this time to grade. They obviously don’t know what we are doing at our school.” She follows this proclamation with an eye roll emoji.

“Oh no! Is this entire three-hours going to be a ‘sit and get,’” Mr. Brown asks frantically, his closing scared emoji conveying the sentiment.

Just then, Mr. Miller, with a smirk of sarcasm on his face, leans into the group of four and whispers, “Yo! Ha! They are teaching progressive strategies with traditional models. I think this

is going to be a long one.”

That is when an audible, collective sigh escapes from the four of them.

This anecdote depicting frustrated educators is not intended to disparage schools or educators, but rather present a poignant example of what this dissertation sets out to do. A narrative case study of three teachers in an inquiry-driven, project-based, technology-infused instructional model (Laufenberg, 2014; Lehmann, 2012), the dissertation provides confirmation, for the practitioners of project-based learning (PBL), that there is a process to this style of pedagogy and curriculum-construction (Angelle, 2018; Bakkenes, et al., 2010; Dewey, 1938; Gil-Galván, 2018; Howard, 2014; Jonassen, 1996; Ochoa, et al., 2004; Papert, 1980; Papert & Harel, 1991; Schoenfeld, 2011; Tamim & Grant, 2013; Thomas, 2000, p. 24). While school environments and content areas are different, and while school districts pay top dollar for top-down professional development on what teachers already know and do, there is valuable information to be gleaned from the voices of math teachers living through the experience of creating non-linear curriculum (Burgess & Bryman, 2002; Marks, 1990; Robinson, 2010).

Teachers and the institutions that they work for have made significant contributions to the PBL model since the model was first defined. There is an important story about these contributions that has been neglected, which has resulted in the loss of knowledge about the process of curriculum creation as teachers and institutions change throughout their life cycles and tenures. The intention of this study is to relay those stories in an academically rigorous investigation using narrative inquiry and “teacher lore” (Brown 2010).

### **Purpose of the Study**

The following pages will reveal the story behind how three math teachers generate curriculum for their schools and what insights they have on the process of curriculum

development inside of a perceived linear content area, such as math. The purpose of this dissertation is to build knowledge that will inform a gap in the current literature regarding “growth and [/or] change of resources, goals, and orientations” (Schoenfeld, 2011, p. 327) by telling the stories of three math teachers as creating curriculum for an inquiry-driven, project-based, technology-infused instructional model (Corcoran & Silander, 2009).

This dissertation will generate a narrative for fellow practitioners and teachers about how these three teachers are combining modern teaching tools with original curriculum development to create non-linear classroom instruction for PBL. Math teachers, along with foreign language teachers, often have a more difficult time in translating lessons from traditional ideas of learning to PBL because of the linear nature of the content areas. There is a common belief that math is a content area that must build upon itself in a specific succession to yield successful results in student learning (Bryman & Burgess, 2002; Marks, 1990; Robinson, 2010). Most high school mathematics are taught in succession —Arithmetic, Algebra 1, Geometry, Algebra 2, Precalculus, and Calculus —thereby perpetuating the perception that one needs to be taught before the other. This study shows how PBL teachers are challenging that linear perception.

### **Rationale for Study**

There is presently a significant gap in the literature surrounding the practice and creation of PBL mathematical instruction (Corcoran & Silander, 2009). The story about these curricula writing experiences uncovers evidence about the components that come together to make non-linear PBL successful for teachers and students (Angelle, 2018; Corcoran & Silander, 2009). There is little in the way of scholarly papers concerning the use of technology for math instruction in a nonlinear PBL curriculum. The teacher stories in this study spotlight this missing knowledge and suggest future research.

This study analyzes multiple sources of data and they are triangulated to corroborate the validity inside the evidence from the sources of data. The sources of data specific to this study are a) four interviews, b) the teacher artifacts, c) the two questionnaires, and d) the triangulation of the data shared with and critiqued by the participants (Cresswell, 2012; Dubnewick, et al., 2018). The research will culminate in a discussion about the stories the participants share about their experience in creating lesson plans inside this specific learning model. The act of creating original curriculum in progressive schools is difficult and these stories serve as an influence and reassurance to other educators inquiring about how teachers are currently navigating these experiences.

As the narrative data is restoried, a natural order begins to appear and the final discussion centers around a structural framework by identifying the themes in the experiences of these three teachers and their use of iterative design. Therefore, this currently closed (Condliffe, et al., 2017) process is opened via a construct of the experiences and stories that have been examined through a meticulous research method that culminates in a discussion that draws context to this study via the Theory of Iterative Design.

### **Problem Statement**

Exploring the personal stories and experiences of teachers in their efforts to create curriculum, without the aid of concrete examples, will explain an otherwise closed process of curriculum building in schools. The problem of not knowing how teachers are creating curriculum for inquiry-driven, project-based, technology-infused instructional models is answered using Dewey's theory of experiential education, as it relates to narrative inquiry, and the tradition of "teacher lore" to illuminate the goals, growth, resources, training, and beliefs

(Angelle, 2018; Bakkenes, et al., 2010; Dewey, 1938; Gil-Galván, 2018; Howard, 2014; Jonassen, 1996; Jonassen, et al., 2003; Ochoa, et al., 2004; Papert, 1980; Schoenfeld, 2011; Stager, 2010; Thomas, 2000).

### **Research Questions**

My central research question is: How are public school mathematics teachers—at the Freeman Schools—using project-based methodologies and leveraging existing technological resources in the development of urban school curricula? And my sub-question is: What influences public school math teachers in their efforts to write curriculum in schools that use laptops as a primary learning tool?

### **The Rationale for the Methods**

I have chosen to use the narrative case study methodology to study (Brown, 2010; Clandinin, 2006; Dwyer, & Davis, 2016; Huber et al, 2013) my three cases because a stand-alone case study would omit significant details about the experiences of the three participants, therefore threatening the findings in chapter four and five. Teacher lore has substantiated the significance of the voice of the teacher making curricular decisions (Brown, 2010). The details in the stories about the experiences of the participants explain the entirety of how math teachers are creating PBL curriculum. The methodology of narrative inquiry opens a three-dimensional space analysis, which gives validity to the role (or space) the researcher holds as an insider collaborating with insiders (Herr & Anderson, 2005). Therefore, during the triangulation of the data, when member-checking is performed, the reflexive role of the researcher is utilized to capture the significant details for findings that may otherwise be left out. This is the methodology I use to expose the closed process of mathematical curriculum writing that needs to be added to the academic knowledge base (Angelle, 2018; Condliffe, et at., 2017; Corcoran &

Silander, 2009).

Condcliffe, et al. (2017) specifically mention the gap in the literature, relating that they “were not able to identify any studies” (Condcliffe, et al., 2017, p. 25) that reveal the creation of PBL by teachers. This revelation by Condcliffe, et al. (2017) explained why teacher-created PBL is a closed process. This gap in the knowledge (Angelle, 2018; Condcliffe, et al., 2017; Corcoran & Silander, 2009) surrounding the creation of PBL mathematical instruction makes it imperative that the smallest details of the teachers’ practices be clear and replicable, as they relate to a community of learners (Angelle, 2018); and the chosen narrative case study methodology will uncover the minutiae in those stories, through the three cases I re-story, and fully discuss in chapter three (Huber et al, 2013).

My adopted research position to conduct a narrative case study was created by reflecting on my research question and the participants through a theoretical lens and the existing literature on the topic (Dwyer, & Davis, 2016). This methodology is one way to get to the answer of how the participants are using OTOLP environments to teach non-linear math in a project-based model. The participants’ experiences have many facets which are important components that will explain the nature of what these teachers are creating. Telling their individual storied responses to their experience will reveal how these facets come together to be arranged into their original curriculum.

### **Significance of the Study**

The findings of this study add to the literature about the creation of PBL curriculum in progressive school settings. There is a significant gap in the literature surrounding the practice and creation of PBL mathematical instruction (Angelle, 2018; Condcliffe, et al., 2016; Corcoran

& Silander, 2009). There is also a need for details about these teaching practices to be shared out via technological connections that can aid in building evidence to guide the advancement of the instruction about non-traditional mathematical instruction (Corcoran & Silander, 2009; Angelle, 2018). Future use of this study will act as a guide for educators who are starting a PBL initiative in their schools or for those who are currently using PBL. This study can be used as a model or starting point for educators interested in studying what other teachers are experiencing while creating a curriculum for inquiry-driven, project-based, technology-infused instructional models.

### **Limitations of the Study**

The limitations of this study are the attempts to authenticate the findings in the narrative case study methodology because it is a collaboration between the researcher and participants (Hart, 1996; Hollingsworth et al., 1993). There are no rigid categories of Truth to describe knowing or epistemology (Hart, 1996, p. 70). This study's foundation is seated in the "hermeneutic cycle rather than a clearly articulated goal-oriented process" (Hart, 1996, p. 70). According to Hollingsworth et al. (1993), the importance of conversation is the struggle to articulate the differences between experience and theory. It is the examination of these stories and conversations that build theory (Brown, 2010). Therefore, the positionality of the researcher is a limitation. As a teacher-researcher in the progressive urban public schools being studied, I remain an insider in collaboration with other insiders (Herr & Anderson, 2005).

Reflexivity is inherent in case study research (Cresswell, 2016). Practicing reflexivity could pose a limitation to my narrative case study if the trappings of reflexivity entangle the researcher's ability to make sense of the data. The tension inherent to reflexivity relates to the notion that the researcher assumes the position of the subject. As such, the lens returns to the researcher, potentially repositioning the researcher at the center of the representation (Mortensen



& Kirsch, 1996). Therefore, it is paramount that I maintain a critical observation positionality that ensures the integrity of findings in chapters four and five (Mortensen & Kirsch, 1996).

Generalizability is also a limitation of this research. This study is conducted in the Freeman Schools. Few schools have started from the outset as a one-to-one laptop institutions with the PBL model. And there are relatively few opportunities where a researcher can be an insider in collaboration with other insiders (Herr & Anderson, 2005) in a public-school setting that grows from the day of inception with a PBL model that includes a one-to-one laptop program.

### **Definitions of Terms**

*Project-Based Learning:* A term that refers to a pedagogical style that can take on many meanings. The meaning aspired to in this study is presented by Mergendoller in *Defining High Quality PBL*, where Mergendoller states High Quality PBL “is an important instructional approach that enables students to master academic skills and content knowledge, develop skills necessary for future success, and build the personal agency needed to tackle life’s and the world’s challenges” (Mergendoller, p. 1).

*Freeman School (FS):* The name of the schools where the teachers are employed and the setting for this research study.

*Inquiry-Based:* “A pedagogical approach that invites students to explore academic content by posing, investigating, and answering questions” (Towns, & Sweetland, 2008, p. 1).

*One-to-one laptop program: (OTOLP)* Refers to a school technology initiative “designed to provide each student with a computer to support academic learning” (Penuel, 2006, p. 330).

*Narrative Case Study: (NCS)* “Narrative inquirers understand that a person’s lived and told stories are who they are and who they are becoming and that these stories sustain them”

(Clandinin & Huber, 2014, p. 15).

*Progressive Education:* An idea in education that is a reaction to traditional education, drawn from the ideas tested by John Dewey and leading school reformers between 1899 and 1916. The term is used to describe ideas and practices that aim to make schools more effective agencies of a democratic society (Dewey 1938, Miller, 1997).

*Traditional Education:* “The traditional [education] scheme is, in essence, one of imposition from the above and from the outside” (Dewey, 1938, p. 20).

*Teacher Lore:* “Teacher lore is a practical form of writing reflectively about critical incidents in the teaching and learning of individual teachers” (Brown, 2010, p. 863).

*Non-linear Mathematics Curriculum* - “Usually learning/teaching is linear. You read a book trying to understand every little piece of information sequentially, beginning at page one, and ending at the last page, or you watch a lecture following the teacher’s progression... [n]on-linear means that you can study topics in the order you want” (Rootzén, 2015, p. 2 & 5).

*Ubiquitous:* “...when it [technology] is ubiquitous, it becomes a part of who we are and how we learn. That is the pathway to helping students understand the world in which they live. When it [technology] is ubiquitous, students learn how to put it away when they want to or they need to. When it [technology] is ubiquitous, it is no longer special. That is the moment when we stop worrying about integrating technology and start concerning ourselves with learning” (Lehmann, 2013).

*Experiential Education:* “Education must be conceived as a continuing reconstruction of experience... the process and goal of education are one and the same thing” (Dewey, 1897). “Learning is the process whereby knowledge is created through the transformation of experience” (Kolb, 1984, p. 38).

## Summary

There are few schools a teacher could work for in the United States that offer full PBL immersion and the participants in this study work in two of them. The participants' experiences during their daily work life overflow with the potential to inform and uplift the current educational landscape. There are important discoveries in the stories the participants tell about their experiences that lead to knowledge about the curricula they author for inquiry-driven, project-based, technology-infused instructional models. These are the stories that grow the current knowledge base and lead to informed practices in PBL education.

The goal is to expose this otherwise closed process of experience to help build upon a conceptual framework that guides the practice of creating original PBL curriculum. There are currently so few examples of this and the need for discourse surrounding these stories about teachers' experiences is paramount to the success of PBL. The scarcity is not because there are other narrative case studies about how teachers are creating math PBL curriculum that falls short of giving examples of teacher experiences. There simply are no concrete examples of teachers creating math PBL units to reference in the current literature (Angelle, 2018; Condliffe, et al., 2017; Corcoran & Silander, 20).

## **Chapter 2: A Review of the Literature**

This chapter is a review of the literature in three similar yet distinct topics. The Freeman Schools have a specific model that incorporates technology to be used alongside the PBL. Therefore, the following distinctions between the similar topics that relate to this study about PBL are highlighted and made discrete. These areas include math in PBL, PBL math and technology, and teachers creating the PBL curriculum (which will build in layers, starting with the basics and moving toward a conclusion about the teacher's experience in creating PBL curriculum).

The bulk of the existing research focuses on quantitative student outcomes and how these outcomes correlate to a treatment that includes various versions of PBL. While teacher attitudes and the use of technology in today's classrooms represent a recurring theme of research through PBL, alongside the various PBL treatments, there is little insight into how the PBL treatments were developed and authored. These descriptions of attitudes, beliefs and/or dispositions toward classroom criteria or classroom constraints (or a school-wide learning model) have a relevant connection to this dissertation. In short, disposition impacts the decision-making process a teacher goes through to create curriculum and is, therefore, a significant component of this analysis. Math is widely perceived as being a linear content area (Marks, 1990; Robinson, 2010; Burgess & Bryman, 2002) and a belief in the linear construct of math has consequences in the way in which PBL curriculum is authored by individual teachers (Bakkenes, et al., 2010; Dewey, 1938; Gil-Galván, 2018; Howard, 2014; Ochoa, et al., 2004).

The following review will show a differentiation of "what" and "how" questions within the literature. This differentiation is used to further organize and make a distinction to identify the differentiation of "what" and "how" questions being asked by the researchers in this literature

review.

There are four major constructs that are important to review in order to show the relationship between the content area of math and the experiences teachers have creating PBL curriculum, including the use of an OTOLP. The literature topics are analyzed in these categories through a three-part theoretical framework: (a) that of Dewey's Theory of Experience (threaded with the commentary about teacher beliefs); (b) through tensions between progressive and traditional pedagogies; and lastly (c) through the tensions of teaching with or without technology in the classroom. The body of literature reviewed frequently features teacher beliefs and attitudes being an important indicator of success or failure for PBL curriculum. The frequency, therefore, makes it important to show how the different researchers/authors came to discuss or conclude that a belief/attitude would have bearing on a progressive educator's total PBL experience.

Dewey (1938) reflects on the dichotomies between the quality of experiences and about progressive versus traditional education. The latter is a major part of his writing in *Experience and Education* (Dewey, 1938) as it is central to his theory, one that is in opposition to traditional education, as defined by Dewey (1938) and Freire (1972). The former is of note because it is the beginning of focused definitions about educative experiences (Dewey, 1938, p.28) and the relationship these experiences have to the future of education.

When Dewey began to unpack his theories in 1938, no one could have foreseen their relevance in relation to the eventual infiltration of computers in schools, beginning in 1993 and peaking to current levels in the late nineties (Watters, 2014). With the arrival of computers in classrooms (and homes) and the advent of the internet, learning and investigation entered the search engine or "Googleable" (Yaman, 2016, p. 19) stage. Questions and answers could be explored through simple Google searches. Entire concepts about books could be read and

understood within fifteen minutes. Almost immediately, teachers took note of changes in student learning and many of them started making decisions around embracing or rejecting these new tools in their classrooms. And the three categories referenced above—(a) that of Dewey’s Theory of Experience (threaded with the commentary about teacher beliefs); (b) through tensions between progressive and traditional pedagogies; and lastly (c) through the tensions of teaching with or without technology in the classroom—begin to fill with information from various researchers and authors studying modern education.

### **Math and Project-Based Learning**

Research on math in PBL brings discernible perspectives to their analyses, drawing from established educational concepts at both the micro and macro levels. The following paragraphs describe the breadth of these perspectives, detailing the macro view of experiential learning, constructivism, and sociocultural learning while drilling down into the micro components that are specific to a particular school or educator. In this section, I clarify the point on the macro to micro scale each researcher is detailing, to clarify how the research is situated in PBL and what components make it relevant to this review.

Angelle (2018) conducted empirical research on PBL literature reviews produced between the years 2000 and 2017, focusing on why science, technology, engineering, and math (STEM) should be taught in grades K12. Angelle (2018) does not include a theoretical framework in the study, although the constructivist learning theory is referenced throughout the chapters. At the conclusion of Angelle’s (2018) literature review, there are two sentences that capture the essence of what needs to be added to the existing knowledge about mathematical concepts being taught with PBL. Angelle (2018) explains that there is a general tendency to view math as a “stand-alone” subject (p. 31). Angelle (2018) continues that, in reality, it is “a language

that all subjects speak” (p. 31). Angelle (2018) concludes that by writing PBL curriculum, math could be infused in an interdisciplinary and “wonderfully successful” way if there was a focus on this connection in the research (Angelle, 2018, p. 31).

Angelle (2018) discusses the “why” of PBL, while Tamin and Grant (2013) delve into “how” learning is impacted and what the teachers are challenged with during implementation periods. While Angelle (2018) fully defines and describes types of PBL, Tamin and Grant (2013) completed a case study of teachers implementing PBL. Tamin and Grant (2013) are also steeped in the Constructivist Theory. However, their references do not date back any farther than in 1999. Instead, Tamin and Grant (2013) glean all of their understanding of constructivism from 21st-century educational writers like Michael M. Grant, Nancy Hertzog, David Jonassen, Jason Ravitz, as well as one from the 20th century. This is significant because Tamin and Grant’s (2013) “Definitions and Uses: Case Study of Teachers Implementing Project-based Learning” is an example of current teacher voice, which is what this dissertation aims to amplify in order to validate that teachers form theory through examining the experiences of themselves and other teachers (Brown, 2010). Tamin and Grant (2013) concluded that “[b]elieving in the importance of PBL as a student-centered constructivist model seems to enable the teachers to work around the challenges of its implementation” (Tamim & Grant, 2013, p. 95). Although Tamin and Grant (2013) don’t specify a need for future research, they allude to professional development being needed to aid with “...the struggle in managing the project environment, in scaffolding, and in assessment” (Tamim & Grant, 2013, p. 95).

In Howard’s (2014) case study concerning the beliefs and practices of successful teachers at a socio-economically challenged school, Howard (2014) also calls for professional development in PBL regarding the analysis of future research. Although Howard (2014) never

directly references PBL, he nonetheless states that a focus on helping teachers to become “comfortable with creating a culture of social learning” and “collaborative learning” activities would be beneficial (Howard, 2014, p. 149). This emphasis on the benefits of collaborative learning is featured throughout the Tamin and Grant (2013) and Angelle (2008) studies, and Angelle (2018) points out that collaboration is a lesser-known key component of PBL (Angelle, 2008, p. 11). The major theoretical thread in Howard (2014) centers around Vygotsky’s Social Development Theory and his belief in the importance of social environments in the process of learning (Howard, 2014, p.146). Although Social Development Theory is not directly relevant to this current project, it is a notable part of the student experience that the teacher may need to engineer at pivotal points of their unit planning.

Howard’s (2014) study is relevant in that it also asks a “how” question, which, on the surface, may appear unrelated to a narrative case study. However, Howard’s (2014) conclusions and observations relating to her examination of those successful teachers in high poverty schools who adapt their beliefs and practices to meet their students’ academic needs are highly relevant. Howard’s (2014) observations of teachers in high poverty situations have relevance to the urban component in this dissertation, especially because the research for this dissertation is situated in a large urban area, where the Pew Report states 200,000 live in extreme poverty (Trinacria & Trinacria 2018). Of equal importance are Howard’s (2014) observations about teachers experiencing success because they planned with components of PBL.

The research Angelle (2018) completed summarizes the significant literature pertaining to PBL and math, which creates a concise example of the timeline mentioned above (Angelle’s [2018] referenced span of 2000 to 2017). Throughout the research, there are positive and negative tensions of past theories colliding with the modern tools and lives of educators. These



tensions become significant because they reveal the attitudes of teachers and students. The most contrarian view of PBL — *Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching* by Kirschner, et al. (2006) — supports Dewey's (1938) Theory. Kirschner, et al.'s (2006) argument against PBL is a simplistic reboot of what Dewey (1938) cautioned readers about in *Experience and Education* (Dewey, 1938). It mirrors Dewey's argument in stating why experiential learning is incredibly valuable by stating:

The belief that all genuine education comes about through experience does not mean all experiences are genuinely or equally educative... For some experiences are mis-educative. Any experience is mis-educative that has the effect of arresting or distorting the growth of further experience (Dewey, 1938, p. 28).

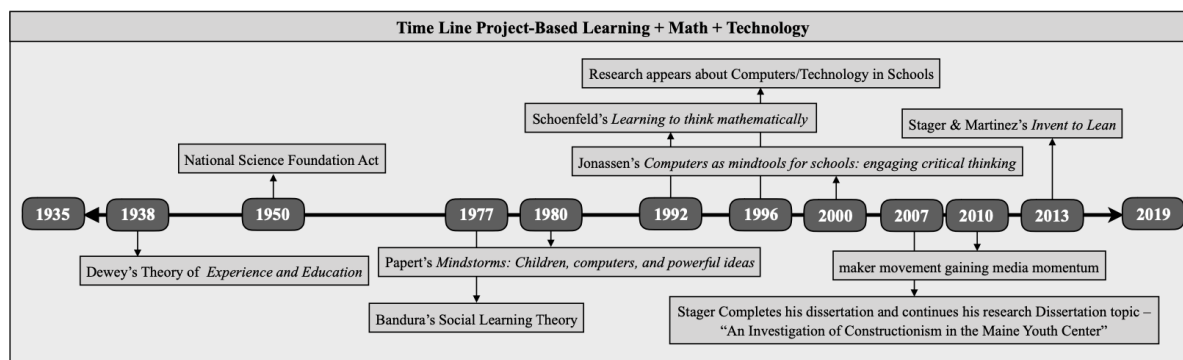
It is here that Dewey is explaining that curators of student experience have to be strategic in the choices they make pertaining to an experience that culminates in internalized learning. These choices, implies Dewey, can dictate whether there will be further growth in knowledge or that growth will be arrested and stop for a student in the moment he/she internalized the specific learning experience. The review above, which is one portion of the literature, shows that math is situated in PBL and illustrates the character of PBL being cross-curricular and that most progressive pedagogues are layering concentrations. Below is a continuation of that cross-curricular character of PBL, which explores the influence technology has had on PBL with specific parameters.

Technology and its influence on the pedagogical style of PBL —in the content area of math —is also a widely researched area; one that requires a specific review of the literature and a

guided timeline to firmly establish the parameters I have assigned in the following review.

**Figure 2**

*Timeline of Literature Pertaining to Technology and Math PBL*



*Note.* This figure depicts a graphic of the overall timeline offered in prose below.

**1938**

This record of the events and scholarly contributions begins with Dewey (1938) when he publishes *Experience in Education*. By this time, progressive education is firmly established, progressive schools have been operating for decades, and the Progressive Education Association is about to turn thirty-years old (Miller, 1997).

**1950**

The next biggest contribution to math education is the National Science Foundation Act of 1950. This Act was a reaction by the government to keep America competitive internationally. In order to do this, grants were created and this act supported both research and education in mathematics, physical sciences, non-medical biological sciences, and engineering (McCartner, 2017); what today's educators would call "STEM" science, technology, engineering and math education.

**1963**

Social Learning Theory emerges in 1963 as Albert Bandura begins to write about a

comprehensive model of learning that accounts for a wide range of learning experiences. The model is structured by integrating the behavioral and cognitive theories from educational psychology. This theory is refined with the help of Richard Walters and, in 1977, Bandura and Walters (1977) create the five tenets of Social Learning Theory (Bandura, & Walters, 1977).

## **1992**

Alan Schoenfeld is a thought leader, teacher, and influential researcher. Schoenfeld's (1992) research parallels this review with *Learning to think mathematically: Problem-solving, metacognition, and sense-making in mathematics*. Then Schoenfeld (2011) makes his scholarly journey to realize that teacher beliefs and experiences are important factors in creating an expert teacher. Consequently, in the discussion section, he writes about the importance of researching teacher experience. Schoenfeld (2011) writes:

“Thus, a major next step in research on helping teachers develop the kinds of expertise described in this volume will be to chart the growth and change of teachers’ orientations, goals, and knowledge as they have the kinds of experiences intended to help them develop expertise” (Schoenfeld, 2011, p. 340).

The kinds of expertise in this quote are “growth and change of teachers’ resources, goals, and orientations” (Schoenfeld, 2011, p. 327). Schoenfeld, (2011) ties teacher beliefs into his research about their expertise when he says, “[T]he first main section stresses the importance of teachers’ and researchers’ beliefs and values – more generally, their conceptual models regarding “what counts” in the act of teaching” (Schoenfeld, 2011, p. 327).

## **1996**

Research about how schools are using technology and computers started to appear in academic writing. These scholarly contributions, while talking about the “how”, also are talking

about the “what” which will become instrumental in creating educational technology as a part of pre-service teacher preparation and an entire industry of educational technology. This is also why, earlier in this dissertation, the term “Googleable” is recognized as starting to have an effect on teacher practice. It is this new verb that also contributes to educational technology establishing itself in schools so quickly after the advent of computers for school use (Angelle, 2018; Heffernan, 2017; Tamin and Grant, 2013).

## **2010**

The maker movement is gaining momentum in the press, even though this movement had been around since the beginning of humans making objects with their hands. The press, scholars, and “makers” name the movement and start to categorize it for education (Martinez & Stager, 2013; Stager 2010).

### **Math and Project-Based Learning with Technology**

Technology and math are made for and from each other. Two parameters, mentioned above, have been defined for the purposes of this review of the literature: first, to analyze the accepted experts of this category; and secondly, to include only the experts that are using or researching technology, in consideration of math and PBL, as a cognitive tool and not as an instructional aid (Papert, 1980; Jonassen, 1996; Thomas, 2000, p. 24).

Seymour Papert emerged as a thought leader in the 1980’s with a concrete methodology that incorporated most of Dewey’s theories and Piaget’s ideas surrounding constructivism. Papert went on to discuss an updated form of constructionism using Piaget’s and Vygotsky’s theories surrounding Constructivism, thereby departing from the educational psychology theories that were dominating the field of educational theory up until that time. Papert was a colleague of Piaget's and co-authored research with him. He then forged his own intellectual path by revealing

how Constructivist approaches to learning math with technology leads to true student creations that manifest themselves in the world as a public entity (Papert & Harel, 1991). Papert and Harel, (1991) discuss the meanings of constructivism and constructionism, relaying the commonalities and historical importance of the two terms while reintroducing the Deweyan construct of education. This expounds on the need to leave room for students to create physical objects in the world because those items will result in learning that can be transferred as the knowledge gained is then built on a strong foundation of complete and personal understandings (Papert & Harel, 1991, Dewey, 1938). Papert and Harl (1991) give anecdotes and real-world examples to make the point that the way a teacher facilitates the learning experience and the actual product that students are empowered to make creates the constructivist experience of learning. This, in turn, leads to the building of knowledge structures that construct a public entity (Papert & Harel, 1991).

About twenty years after Seymour Papert started at the Massachusetts Institute of Technology (MIT) and coinciding with the publication of his book *Mindstorms: Children, computers, and powerful ideas*, David Jonassen started publishing and establishing himself as the next voice in using technology as a cognitive tool. Jonassen (2000) wrote a book with an acknowledgment in its title toward the previous work of Papert (1980): *Computers as mindtools for schools: Engaging critical thinking*. In this book, Jonassen (2000) develops and explains a mindset for teachers to use when creating a curriculum for students who are engaged in using technology for learning. This book includes ideas and actual lesson plans for some of the most popular software. Shortly before the book came out, Jonassen, Carr, and Yueh (1998) wrote “Students cannot use Mindtools as learning strategies without thinking deeply about what they are studying” (Jonassen, et al., 1998, p. 25). Jonassen, et al. (1998) list the many types of tools

available to teachers, citing dynamic modeling tools, mind-mapping tools, and semantic networking tools. Jonassen, et al. (1998) say:

Spreadsheets also may be used as Mindtools for amplifying mental functioning... spreadsheets can change the educational process when working with quantitative information. Spreadsheets model the mathematical logic that is implied by calculations. Making the underlying logic obvious to learners should improve their understanding of the interrelationships and procedures. (p. 28)

This description of spreadsheets encapsulates the precise strategy behind the use of these tools, illustrating to educators the value software can offer when viewed as a “Mindtool”.

Jonassen, et al. (2003) update a previous larger nod to Papert’s work called, *Learning to solve problems with technology: A constructivist perspective*, which updates the previous edition by Jonassen, et al. (1999). Both books explain the constructivist philosophy and the move from “instructor teaching” to “student learning.” In addition, the second book by Jonassen, et al. (2003) goes into problem-solving that engages students through community building, using the various technology tools available in school settings (Jonassen, et al., 2003).

Gary Stager is the next scholar and researcher to continue the trend of technology immersed in constructivism and constructionism learning theories. He was a pupil of Seymour Papert and is an archivist of Papert’s work. Stager (2010) writes about the importance of constructionist learning and the contribution “mathematical thinking” makes to the overall experience of constructing knowledge (Stager, 2010, p.16).

*Invent to Learn* was co-authored by Stager and his wife, Sylvia Martinez in 2013. This book is a culmination of Stager and Martinez’s experiences and research. And, like Jonassen’s

(2000) book, *Computers as mindtools for schools: Engaging critical thinking*, it also includes specific lesson plans for teachers to experiment with in their classrooms. Martiez and Stager (2013) set up a historical foundation that explains “making” and supports learning with project-based techniques by citing writings of the above-mentioned scholars and more. Stager and Martinez (2013) point to, reference, and quote, Papert and his MIT colleagues, Maria Montessori, those using the Reggio Emilia approach, Neil Gershenfeld, Mark Frauenfelder, Zephyrus Todd, and Nicholas Negroponte, to name a few. Nicholas Negroponte is a thought-leader that Martiez and Stager (2013) distinguished as one of the scholars beginning the evolution of the maker movement by “heading into several different directions including biology, chemistry, and material science” (p. 31).

Stager is the final researcher and expert for this section. Stager represents the most current research and practice of using PBL in conjunction with mathematical thinking and technological tools, citing the tools as cognitive constructors of knowledge. This stands in stark contrast to the use of these tools as simple instructional aids.

The above section illustrates the influence technology has on PBL and the specific trajectory the union of technology and PBL took, as well as how the two appear today. This next section concludes this literature review in two ways: one, by rounding out the concepts that closely align with this dissertation; and, two, by describing where the literature has gaps, making the final point from the introduction about the teacher’s experience in creating PBL curriculum.

### **Teachers Creating Project-Based Learning Curriculum**

Unlike the previous section, this section does not require parameters to narrow the amount of literature that falls within its category. Literature about teachers creating original PBL is practically nonexistent (Condliffe, et al., 2017). Therefore, the following section aims to

clarify what literature has been published on the topic in order to build this last part of the scaffold that will frame what this dissertation will add to the current literature.

Condliffe, et al. (2017) wrote and researched a comprehensive literature review spanning the knowledge of PBL from 1998 to 2016 while referencing earlier literature to situate the review in a broader context. Condliffe et al. (2017) frame their criteria for PBL in the first section and then proceed to write about four subsections of PBL. The research revealed: “Although one can speculate that designing a PBL curriculum from scratch would be incredibly challenging for a teacher, we were not able to identify any studies related to the challenges teachers face in planning their own PBL curriculum from the outset” (Condliffe, et al., 2017, p. 25). The researchers have very little to review in this category. That said, there are three pieces of writing that can give context to teacher-created PBL curriculum: a dissertation by Morgan (2018) and two journal entries by Bakkenes, et al. (2010) and Gil-Galván (2018). Although these pieces shed some light on the process, they generally lack the intimate details of the process that takes place during the teacher’s experience of writing PBL curriculum.

Morgan (2018) concludes two major themes drawn from the study of four veteran teachers as they construct knowledge in a new PBL environment. The first theme: “Teachers blend their personal and professional experiences as they create a PBL curriculum” (Morgan, 2018, p. 110). Morgan (2018) gives specific examples about how teachers use experiences prior to teaching in the creation of curriculum, especially those experiences that focus on “community, environment, family, and [/or] mentorship” (Morgan, 2018, p. 111). Other teachers in the study incorporated ideas from their traditional classrooms that made sense with developing PBL. One example given was the use of “playlists” (p. 111) to develop teacher-student relationships, that can aid in the community building necessary for PBL success (Angelle, 2018; Morgan, 2018).



The second theme: “Consistent access to resources... could further benefit and develop teachers’ skills as they relate to the creation of a PBL curriculum” (Morgan, 2018, p. 110). The question Morgan (2018) asks is, “How do veteran middle school teachers, new to project-based learning, construct knowledge as they create a PBL curriculum?” (Morgan, 2018, p. 109). Morgan (2018) reveals a what answer more than a how answer and the reader is able to glean what goes into the construction of a PBL curriculum and what resources are needed. The how is left unanswered. Gil-Galván (2018) sites a framework that comes close to answering this how question for veteran higher education teachers. The answer Gil-Galván (2018) offers is an example of a specific curriculum developed over time that is created by teachers who have lived the experience of going from traditional styles of pedagogy to progressive PBL styles of pedagogy (Gil-Galván, 2018, p. 47).

Bakkenes, et al. (2010) are quick to note, “A sound conceptual framework for describing processes of teacher learning in professional practice does not yet exist” (Bakkenes, et al., 2010 p. 533). And by acknowledging this need, Bakkenes, et al. (2010) aimed their study to “contribute to such a conceptual framework” (Bakkenes, et al., 2010 p. 533). Bakkenes, et al. (2010) focus on two areas of investigation: learning activities and learning outcomes. Learning activities are subdivided three ways: (a) experimenting, (b) getting ideas from others, and (c) reflecting practices (Bakkenes, et al., 2010 p. 538). And learning outcomes studies include (a) changes in practice, and (b) changes in knowledge or belief (Bakkenes, et al., 2010 p. 538). Gil-Galván’s (2018) research agrees with and details why teacher beliefs and knowledge are so critical for teachers in learning how to produce PBL curriculum. Gil-Galván (2018) also emphasizes the importance of teachers learning together in a cooperative community. Within this community, they share difficulties, achievements, and coping as a group with the dynamics of

the learning process (Gil-Galván, 2018, p. 51).

Bakkenes, et al. (2010) ask four questions to explore the process of teacher learning:

(a) Which learning activities do experienced secondary school teachers undertake when dealing with educational innovations? (b) Which learning outcomes do experienced secondary school teachers report? (c) How are teachers' learning activities related to the learning outcomes they report, in terms of changes in knowledge and beliefs, emotions and practices? (d) How is the type of learning environment related to the learning activities teachers employ and the learning outcomes they attain? (p. 536)

Bakkenes, et al. (2010) quantitatively factor all of the categories to test the questions and hypotheses and mathematically conclude:

Teachers reported learning mostly through experimentation and reflection on their own teaching practices. They seem to learn much less by external input like the ideas from others, such as colleagues or authors of professional literature. Yet, there appear to be large individual differences among teachers in the learning activities they employ. (p. 544)

The above conclusion reached by Bakkenes, et al. (2010) is reminiscent of Gil-Galván (2018), specifically the comments on teacher resistance to “external input.” It concludes that it is normal in the beginning of a change-over from traditional education to progressive education. Gil-Galván (2018) insists that the creation of the [teaching] team is crucial for developing a culture of exchange, whereby ideas, views, and practices can become transparent and can add to the learning teachers need to experience to ensure the transition to instructing and creating PBL

curriculum (Gil-Galván, 2018, p. 50).

This section of the literature review has highlighted that the creation of original PBL curriculum is difficult. It has also added to the previous section's conclusions that PBL curriculum cannot be created or practiced in a vacuum (Angelle, 2018; Bakkenes, et al., 2010; Condliffe, et al., 2016; Gil-Galván, 2018; Howard 2014; Morgan, 2018; Tamim & Grant, 2013). Practitioners of perceived non-linear content areas, like teachers of math (Burgess & Bryman, 2002; Marks, 1990; Robinson, 2010), are in need of real-world examples to frame the experiences they will go through in order to create a truly progressive curriculum that is pedagogically seated in PBL. The upcoming conceptual framework section will further root the previous ideas, in theory, lay the groundwork for this dissertation, and continue to reveal possibilities concerning teacher experiences in creating math PBL curriculum.

### **Conceptual Framework**

Experiential education is a philosophy that describes the process that usually occurs between a teacher and student that infuses direct experience (Dewey, 1938). Experiential learning is and can be understood as discrete out-of-the school classroom activities, such as field trips, hands-on activities, and/or service-learning. All three examples rate high on the criteria scale for experiential learning (Gentry, 1990, p. 20), which is why these examples of experiential learning are discussed in this conceptual framework. However, the focus of this dissertation is on the wider definitions perceived by Dewey (1938), later by Rogers (1969), and also Hoover and Whitehead (1975). Rogers (1969) describes this wider definition having a “quality of personal involvement” (p. 5) and Thomas (2000) notes the defining features of PBL as: “...centrality, driving question, constructive investigation, autonomy, and realism” (Thomas, 2000, p.6). Finally, another way to describe the generally accepted definition of experiential learning is

offered by Hoover and Whitehead (1975) when they write that “experiential learning exists when a personally responsible participant cognitively, affectively, and behaviorally processes knowledge, skills, and/or attitudes in a learning situation characterized by a high level of active involvement” (Hoover & Whitehead, 1975, p. 25). Progressive experiential learning is about getting out of the classroom for experiences. It is also about an internalized construct of meaning that is built off of an external experience that has an artifact that is physically, or digitally tangible (Dewey, 1938; Papert and Harel, 1991; Stager, 2010).

Dewey dedicated the entirety of his work, *Experience and Education*, to explain and describe this type of “progressive education”. This work and the expression of this philosophy represents a turning-point in education, as well as an acknowledgment to ancient Greek practices of pragmatic learning (Dewey, 1938, p.7). It is important to remember that the research conducted for this study is of the teacher’s experience as a learner. The focus is on the teacher as learner in the process of producing PBL units for students, and the experiences of teachers in developing PBL curriculum for those students in an inquiry-driven, project-based, and technology-infused instructional model.

Carver’s (1996) description of the role of the teacher offers a reference point for the target area of my research. Carver (1996) highlights the tasks teachers of PBL are charged with; for example, cultivating environments and resource analysis and distribution (Carver, 1996). Most importantly, in relation to the relevance of my study, Carver (1996) notes that teachers are part of the healthy functioning organization of experiential education and that teachers are also students, engaged in what is described as the “ABC’s”: agency, belonging and competence (Carver, 1996). Carver (1996) states that teachers are “senior members of learning communities” (Carver, 1996, p. 154). Experiential education’s fulcrum is what the teacher is able to interpret,

produce, and model. This fulcrum is what this study is aimed at investigating. Using the Deweyan experiential education lens embedded in “teacher lore” will enable me to focus on how teachers are going through a process of learning that parallels student learning and show that it can be observed and recorded to help other practitioners. This addition to the available literature will be important to schools immersed in inquiry-driven, project-based, technology-infused instruction that are seeking to learn from the teacher experiences.

There are direct influences and delineations that need to be clarified so that the theoretical framework used for this study is transparent and applicable to the research question and methodology. As Seaman, et al. (2017) points out, there is little evidence of Dewey using the phrase “experiential learning.” However, the use of the word experience in Dewey’s writing earned Dewey “...a reputation as a proponent of experiential learning throughout the second half of the 20th century” (Seaman, et al., 2017, p. NP3). The influence of experiential learning—and, more broadly, experiential education —on education started to take form in America in and about the 1960s (Seaman, et al., 2017).

Seaman, et al. (2017) write that Kolb (1984) provided the clearest and most influential model of experiential learning when he wrote, “Learning is the process whereby knowledge is created through the transformation of experience” (Kolb, 1984, p. 38). And herein lies the difference in the development of these two closely related concepts. Dewey speaks about the process of learning that occurs between the teacher and the student when it comes to experience, while Kolb (1984) alludes to the learning transformations that occur for the student. This study focuses on teachers and the process they go through, thereby maintaining close alignment with Dewey’s theory of experiential education and the processes taking place.

For the purposes of this dissertation, the participants are both teachers and students

simultaneously in their process —the process being the act of creating curriculum, not the transformation that takes place from the application of a curriculum or teacher-imposed experience. In fact, this is where the narrative inquiry, and the methodology used for this study overlap and the conceptual framework and methodology start to complement each other inside of the “teacher lore”. When defining narrative inquiry, Clandinin and Connelly (2000) evoke Dewey’s name in order to clarify how the teacher experience is to be understood when using this methodology. This is because Dewey’s theory of experience is used to frame a metaphorical three-dimensional narrative inquiry space, by which it becomes the lens of analyzation (Clandinin & Connelly, 2000). Chapter three will discuss, in-depth, where the conceptual framework and the theoretical framework overlap by detailing how Dewey’s theories of experience help define the methodology and the three-dimensional space approach used for analysis.

Dewey (1938) states that a theory that forms a philosophy in education exposes a conflict and that it is then the “business of an intelligent theory of education” not to take sides. Rather, it is critical —to creating a plan —that it is inclusive and represents all “practices and ideas” of the opposing sides (Dewey, 1938, p. 7). Part of Dewey’s inclusive plan was to have teachers be creators of experience, while simultaneously being learners along with their students. This is not an original idea, as he contends to have borrowed it from “fundamental practices of the past,” specifically the principles of education modeled by the ancient Greeks (Dewey, 1938, p. 7). This is the foundation upon which Dewey builds his theory that teachers are the connectors of growth —their own and that of their students. This growth is framed by a teacher’s use of knowledge to select and arrange the conditions that influence a student’s present experience (Dewey, 1938, p. 78). This experience, in turn, is also shared by the teacher as the teacher learns in tandem with

the student, a simultaneous meta experience the teacher is having that informs and refines their curriculum.

This section discussed the history of Dewey's theory of experiential education and illuminated a path through the transformation that took place from Dewey's experiential education into experiential learning. In this next section, I will give a brief overview of the literature that relates to this research project. There are two parts to my philosophical foundation, both of which will be explained briefly as these parts are interwoven throughout the entirety of this theoretical framework and are mostly explained in the previous sections.

The phenomena in my theoretical framework will become evident as commonalities in the teacher's experience begin to surface. The commonalities of the teacher's experience will define the phenomena that my theoretical framework will support. These commonalities are discussed and applied to Dewey's theory of experiential education and they will tie together the significance of these occurrences through the triangulation of storied and non-storied data. In regard to this, an emphasis must be placed on the idea that "... [s]tories are not to be treated lightly as they both carry and inspire significant obligations and responsibilities. Stories must be preserved and drawn from, as they are at the heart of how we make meaning of our experiences of the world" (Huber et al, 2013, p. 214). Clandinin (2006) writes about the need for careful delineation of terms and assumptions and the importance of the Deweyan view of experience to this methodology. The metaphorical space that is defined through this methodology of research lies in parallel to all aspects and considerations Freeman teachers are theoretically and realistically dealing with every time they write curriculum (Clandinin, 2006). Clandinin and Connelly (2000) write about this metaphorical space and frame it as a space defined by the characteristics of "...interaction (personal and social), continuity (temporality), and situation

(place)” (Bukoski & Hatch, 2016, p.105; Clandinin & Connelly, 2000). Understanding these phenomena will aid in revealing the core lessons of the stories that are told by the teachers living the experience of teaching in an inquiry-driven, project-based, technology-infused instructional model (Lehmann, 2012; Laufenberg, 2014).

There are therefore two guiding philosophies in my theoretical framework: Progressivism and Constructivism. There is an obvious choice in Progressivism, as PBL does not adhere to nor can it fit into the “Banking” Concept (Freire, 1972) of education. And John Dewey “...was arguably [the] most influential figure in educational Progressivism” (Theobald, 2009). Savery and Duffy (1995) consider PBL to be the best example of a constructivist learning environment. Savery and Duffy (1995) write, “[c]onstructivism is a philosophical view on how we come to understand or know” (Savery & Duffy, 1995, p.2). Savery and Duffy (1995) then connect PBL by stating, “...we have found one application that seems to us to almost ideally capture the principles [of constructivism] --[is] the problem-based learning model” (Savery & Duffy, 1995, p.7). This is the most obvious philosophical construct to support this dissertation’s theoretical framework. However, it is important to know where ideas come from and how they can be applied with an academic lens to describe complex research and theoretical frameworks.

### **Summary**

The symbiotic relationship between early progressive education theories and modern 21st- century school curriculum could not have been forecasted during the early part of the 20th century (Lehmann, 2012, Stager, 2002). The shift from the industrial revolution to the technological revolution created space and resources that demand the progressive education theories to make sense out of the curriculum teachers are being asked to create and, in most cases, forced to perform. PBL is a vast chasm of pedagogy that is begging for the construct and



the classifications pre-21st century philosophers conceived of and designed. The creation process of PBL needs to be identified and defined so that educational systems can move forward in a positive direction, enabling teachers to create PBL with the knowledge of a true definition. This definition should not be constructed to limit the autonomy of teachers. Rather, it is a pathway to rule out the parts of education that do not fit into the PBL model, thereby making curricular decisions about what to include in a student's experience that will build knowledge in a fashion that is easier for all practitioners of PBL. The previous literature review and conceptual framework start to identify the various strands of PBL being created and have revealed a hole in the present literature surrounding what teachers experience as they create PBL curriculum.

### **Chapter 3: Methodology**

In this chapter, I explain why I chose this research topic and give a rationale for my methodology. Then I will go into detail about the methodology to describe the setting, the case, the instrumentation, validity, reliability, and procedures. Finally, I will summarize all of these items into a concise methodology that will transition to the results in chapter four.

#### **Overview**

I am uniquely positioned, inside the Freeman School model, to tell the stories of three teachers' experiences because, for the last fifteen years, I have been teaching, learning, and working alongside these curriculum creators. I have watched three communities of teachers build, implement, and revise their curricula. I chose to tell a portion of that story with hopes that it will resonate with other teachers and school leaders using PBL models in order to formulate mathematics curricula. Mathematics is considered to be one of the hardest subjects to teach successfully using a PBL model. It is also one of the most difficult content areas, for teachers already teaching, to look to for success in a PBL model. Watching the above-mentioned schools grow, and having read the available literature, convinced me that there is an important story to share about the construction, implementation, and revision of curriculum through the lived experience of three participants in this study.

In order to answer my research questions, I conducted a narrative case study of three urban public school math teachers creating curriculum, in a modern progressive educational setting, using an inquiry-driven, project-based, and technology-infused instructional model (Lehmann, 2012; Laufenberg, 2014). These case studies are seated in teacher lore (Brown, 2010) and in Dewey's theory of experiential learning (Dewey, 1938). I believe imparting the stories about these teachers and their experiences is the only way to reveal the multitude of layers

involved in creating their curriculum. I specifically chose math teachers because their content area, traditionally perceived as linear, is the most difficult to conceptualize in a non-linear PBL model (Burgess & Bryman, 2002; Marks, 1990; Robinson, 2010). There is also a need in the current literature surrounding the practice of PBL to examine the details of its implementation. Currently, what is available describes a PBL treatment and the outcomes for students in discrete learning environments or the study of a learning community's transition from a traditional model to PBL. These studies tend to yield learners outcomes or how teachers/departments acclimate to PLB during the transition from traditional teaching methods to PBL methods.

### **Methodology**

The methodology for this research is a narrative case study with multiple cases because a stand-alone case study would omit significant details. The gap in the knowledge base (Angelle, 2018; Corcoran & Silander, 2009) surrounding PBL mathematical instruction consequently makes it imperative for the smallest details of the teacher's practice to be clear and replicable as it relates to communities of learners (Angelle, 2018); this methodology will uncover that minutia (Huber et al, 2013). These case studies are analyzed in the tradition of teacher lore and three-dimensional space, seeking to reveal and analyze the complexities of curricular decision making (Brown, 2010) by the three participants. The aim of this study is to carry on the tradition of teacher lore that “respects the voices of practitioners and seeks to honor their experiences” (Brown, 2010, p. 864). This is in recognition of two things: one, that this method of research is a “response to academics criticizing the apparent lack of theoretical foundation for individual teachers’ decision making processes” (Brown, 2010, p. 864) and, two, “that building teaching theory is personal rather than academic [and] practical rather than distant” (Brown, 2010, p. 864).

I adopted the narrative case study methodology after careful academic reflection on my research questions, the existing literature on the topic (Dwyer, & Davis, 2016), and the different methodologies that could relay the truth about the experiences of these three teachers. The methodology of a narrative case study, coupled with teacher lore and three-dimensional space analysis, is the most detailed way to reveal how the teachers, in this study, are creating math PBL units in the Freeman School Model, which is inquiry-based and technology-infused.

Many facets of this work represent important variables that go into explaining the nature of how these teachers are creating math PBL units. These specific facets are revealed by telling the individual stories about pedagogical practice. To frame the narrative case study setting further, it is a group, culture, and common language study about what is occurring in this particular set of circumstances inside this type of learning model, specific to two schools.

Clandinin (2006) writes about the need for careful delineation of terms and assumptions and the importance of the Deweyan view of experience to this methodology. Clandinin (2006) informs researchers that “careful uses and distinctions of terms” are important because “narrative ways of thinking about experience” are the “interweaving of narrative views of phenomena and narrative inquiry” (Clandinin, 2006, p.45). And through the

...Deweyan theory of experience to conceptualize narrative inquiry, they [Clandinin and Connelly] developed a metaphor of a three-dimensional narrative inquiry space, a space that draws upon Dewey’s criteria of continuity and interaction as well as his notion of situation. The three dimensions of the metaphoric narrative inquiry space are: the personal and social (interaction) along one dimension; past, present and future (continuity) along a second dimension; place (situation) along a third dimension. (Clandinin, 2006, p.46-47)

The metaphorical space defined through this methodology of research runs parallel to all facets the Freeman Schools teachers are theoretically and realistically dealing with every time they go to write curriculum (Clandinin, 2006). The teachers who live the experiences of teaching in these particular schools tell their stories about their circumstances teaching in the Freeman school setting and the Freeman School PBL model.

Above I explained the reasons for adopting the narrative case study methodology for my three cases. Next, I will describe and define the methodologies, which include narrative inquiry, teacher lore, and case study.

### **Research Tradition of Teacher Lore**

Teacher lore specifically “seeks to reveal and analyze the complexities of curricular decision making” (Brown, 2010, p. 863). Brown (2010) asserted, “As a separate research method, teacher lore became popular during the late 1980s continuing through the 1990s” (p. 683) and it has a clear distinction that separates the research method from case study methodologies (Brown, 2010). Brown (2010) declared a position —drawn from edited volumes of teacher lore—that asserts a basis for grassroots educational reform can come out wholly told of teachers’ stories. This study is the story of how teachers are making curricular decisions in order to add to the knowledge of curriculum studies and PBL creation. Brown described teacher lore as the voices of the teachers who engage in teaching day-to-day, therefore they are part of the ongoing professional conversation and can make astute commentary on what it means to teach and what it means to be well educated (Brown, 2010, p. 683). Brown (2010) maintains that “[t]eacher lore is a practical form of writing reflectively about critical incidents in the teaching and learning of individual teachers [and] [t]hough not theoretical in the traditional sense of relying on professional literature as the basis for decision making, teachers form theory

through examining the experiences of themselves and other teachers” (Brown, 2010, p. 863).

### **Research Tradition of Narrative Inquiry**

Clandinin and Huber (2014) claimed that “[n]arrative inquirers understand that a person’s lived and told stories are who they are and who they are becoming and that these stories sustain them” ( p. 15). Creswell (2007) said that narrative research originated from “literature, history, anthropology, sociology, sociolinguistics, and education” (Creswell, 2007, p. 54). Education research has taken “a sharp turn to narrative” (Clandinin & Connelly, 2013, p. 10) since the late 1980’s and Dewey’s (1938) theory of experience is most often cited as the philosophical foundation of narrative inquiry (Clandinin & Connelly, 2000). This “sharp turn” can be attributed to two main shifts in the social sciences and research. First, the postmodernist emphasis on reflexivity; the positioning of oneself in research or the analysis of the research. And, second, social theory and the emphasis of individual agency over social structure (Lather 1992). Clandinin and Connelly (2006) asserted that “Narrative inquiry, the study of experience as a story, then, is first and foremost a way of thinking about experience” (p. 375). Interaction and continuity are the two principles that Dewey (1938) discussed and that are paramount to the “learner and what is learned” (Dewey, 1938, p. 10). Clandinin and Connelly (1990) argued that Dewey’s (1938) assertions about interaction and continuity are the main ingredients for narrative inquiry as it is understood in three-dimensional space. Those three-dimensions are described as “inward, outward, backward, forward, and [specifically] situated within place” (Clandinin & Connelly, 2000, p. 49). Further defining three-dimensional space as it relates to narrative inquiry, Clandinin and Connelly (2000) go on to specify that:

...any particular inquiry is defined by this three-dimensional space: studies have temporal dimensions and address temporal matters; they focus on the personal and the social in a

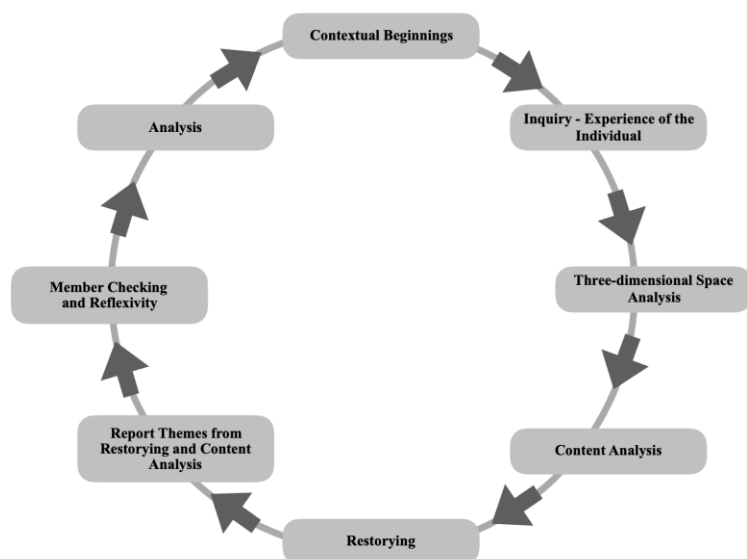
balance appropriate to the inquiry, and they occur in specific places or sequences of places. (p. 50)

The final pieces that bring narrative inquiry into focus along with the frame of the experience of the individual are “the social, cultural institutional narratives” (Clandinin & Rosiek, 2007, p. 42-43) that can be written into storied text by studying alongside of a person’s lived experience by listening, observing and interpreting (Clandinin & Rosiek, 2007, p. 42-43). Clandinin and Connelly (2006) regard these stories, shaped by people living them, to be the portal through which a person enters the world and by which their experience of the world is interpreted and made meaningful (Clandinin & Connelly 2006, p. 375).

There are three factors that come together to make this study a possibility: (1) the lived experience of the teachers that are writing the curriculum; (2) the observations I am able to make as the researcher in an insider’s role, and (3) the collected data and artifacts. The nature of these three factors can only be described and critiqued through a narrative case study. I make this assertion because the underlying tenets of narrative inquiry are inspired by Deweyan experience. The core of this study is human lives and their lived experience is the source of important knowledge and understanding as it is applied in narrative inquiry because narrative inquiry is the way of understanding experience (Clandinin & Connelly, 1990). This collaboration is the narrative inquiry of stories lived and told (Clandinin & Connelly, 2000, p. 20).

## **Figure 2**

The Cycle of Narrative Inquiry within Three-Dimensional Space Analysis



### Research Tradition of Case Study

The research presented here is considered a multiple case study composed of three high school teachers in a PBL, technology-infused model. Each individual teacher represents a single case study and the individual is the primary unit of analysis. A narrative inquiry with multiple case studies has been selected to strengthen the precision, validity, and stability of the findings (Miles & Huberman, 1994).

Mills, et al (2010) touted that “[c]ase study methodology has a relatively long history within the sciences, social sciences, and humanities.” (Mills, et al, 2010, p.xxxi). As researchers turned to phenomena and the details within contextual occurrences the case study approach gained popularity (Mills, et al, 2010, p.xxxi). Mills, et al, (2010) stated:

Case selection is the rational selection of one or more instances of a phenomenon as a particular subject of research. The reasons for selecting a case or cases vary from interest



in the particular case to theoretical considerations. The relevance of the case or cases for the research objective is the most important criterion for selection. (p.61)

The aim of these multiple case studies is to create knowledge and understanding to establish a set of standards for good PBL teaching practices by gaining experience through exposure to a particular phenomenon within the Freeman Schools learning model (Mills, et al, 2010, p.99). Stake (1995) cited posing research questions, gathering data, and analyzing and interpreting data as a series of necessary steps for completing a case study. Yin (2013) suggested another schema for conducting a case study that consisted of five major parts: (a) presenting a clear and adequate specification of the theoretical issues and, from this, the questions that frame the study, (b) clearly defining the unit(s) of analysis, including possible sub-units if these are warranted, (c) deciding on the appropriate number of cases to explore within the study, (d) clearly specifying the selection criteria for choosing the cases studies, choosing an appropriate and effective data collection and analysis strategy, and (e) developing appropriate tests to ensure the validity and reliability of the approach taken in conducting the case study.

Above I have explained that this compilation of three narrative case studies will be analyzed through teacher lore and the three-dimensional space approach. It is important to explain the exact experiences of the three teachers in this study so that other practitioners can understand the situation of each teacher. This will ensure a clear understanding of how to benefit from and use the information that explains how teachers are creating math PBL curriculum that is inquiry-based and technology-infused. A case study is employed to create a clear distinction between the three participants. Narrative inquiry is used to collect and restore the experience of the participants. Teacher lore will honor the voices of the participants and their efforts to add to

the academic knowledge surrounding the creation of math PBL curriculum in the Freeman School Model. And finally, the three-dimensional space approach is used to define and detail the exact situation the participants inhabit while experiencing the creation of math PBL curriculum in the Freeman School Model.

**Description of the Case.** This narrative case study consists of three public school mathematics teachers, practicing at two high school campuses situated in a large urban area in the northeastern United States, and teaching under the umbrella of the Freeman School's teaching and learning model. The three participants voluntarily opted into this narrative case study to tell their stories about how they are authoring curriculum for an inquiry-driven, project-based, and technology-infused instructional model. The participants have varied levels of experience. That said, each has enough experience to describe, with familiarity, the Freeman School's PBL teaching model.

**Case Selection and Setting.** I conducted my study in two small high schools located in a large urban area of the northeastern United States. The school's demographics also mimic those of the city itself. They use the same model and name and I call them the Freeman Schools: Freeman School North and Freeman School West... I collected data and conducted interviews primarily online. The participants work in these small schools of 500 students or less, within a project-based learning curriculum, and a one-to-one laptop program.

### **Instrumentation and Analysis**

This study adheres to accepted qualitative research instrumentation. Multiple sources of data are analyzed and triangulated by which the validity is corroborated inside the evidence from the sources of data. The sources of data specific to this study are: (a) the four interviews, (b) the

teacher artifacts, (c) the two questionnaires, and (d) the triangulation of the data shared with and critiqued by the participants (Cresswell, 2012). The accepted analytic lens for narrative case studies is three-dimensional space. In the next section, I will define this lens and explain how it relates specifically to these three case studies.

**Three-Dimensional Space.** I analyze the teacher stories in this study through the lens of three-dimensional space. Three-dimensional space gives this study a powerful framework to describe three teachers' experiences. This perspective is a position of wonder rather than a position of already knowing and inquiry is used to compose knowledge that builds to guide the process of this research (Caine, et al., 2013). Clandinin and Connelly defined specific components of three-dimensional space (2006) as “temporality, sociality and place” (p. 479-481). Clandinin and Connelly discuss this analysis being “derive[ed] from the Deweyan view of experience (particularly situation, continuity, and interaction) ... [and] ...that “this framework allows... inquiries to travel-inward, outward, backward, forward, and situated within place” (Clandinin & Connelly 2000, p.49). Clandinin and Connelly (2006) provide the definition of these three words of analysis in the context of narrative inquiry as follows:

1. Temporality - “Events under study are in temporal transition” (Connelly & Clandinin, 2006, p. 479). In narrative inquiry, it is important to try to understand people, places, and events from their past, present, and future, keeping in mind that all six of these items are in constant transition.
2. Sociality - There are two kinds of sociality in a narrative inquiry: (a) personal and social conditions, and (b) the relationship between participant and inquirer. In the first kind, “[n]arrative inquirers are concerned with personal conditions and, at the same time, with social conditions. By personal conditions we mean the feelings, hopes, desires, aesthetic

reactions, and moral dispositions [of the inquirer and study participants]” (Connelly & Clandinin, 2006, p. 480). In the second kind, “inquirers are always in an inquiry relationship with participants” (Connelly & Clandinin, 2006, p. 480) lives and they cannot subtract themselves from those relationships (Connelly & Clandinin, 2006, p. 480).

3. Place - “The specific concrete, physical and topological boundaries of place or sequence of places where the inquiry and events take place” (Connelly & Clandinin, 2006, p. 480). In narrative inquiry, the specificity of the location of the place is crucial and a narrative inquirer needs to think through the impact of place on the participants’ experiences.

With those definitions in place and when thinking about these stories from perspective of wonder rather than knowing (Caine, et al., 2013), and accepting that a distinguishing feature of narrative inquiry is a focus on narrative understandings of experience, the researcher has a responsibility to practice thinking with these stories rather than thinking about these stories (Morris, 2001). Ultimately, it can be concluded then that researchers or inquirers cannot be subtracted from the inquiry relationship with the participants and careful detail must go into explaining the existing tensions inherent to the narrative inquiry research methodology.

This study fulfills the above-mentioned responsibility by answering the question: how are public school mathematics teachers—at the Freeman Schools—using project-based methodologies and leveraging existing technological resources in the development of urban school curricula. And by utilizing the three-dimensional space approach, I have analyzed the participant’s interview data through the past, present and future accepted methodology, to parse out significant patterns and information within the data sets (Clandinin & Connelly, 2000; Marsh et al., 2019).

### **Description of the Three-Dimensional Space**

Three-dimensional space is the analysis used to provide continuity and form rich, thick descriptions (Merriam & Tisdell, 2015) about this study's data and the experiences of the teachers' while creating PBL mathematics curriculum.

Continuity is related to learning about these experiences, and experiences grow out of other experiences and lead to new experiences. Furthermore, these interactions occur in a place or context, such as a school classroom or a teacher's lounge. (Ollerenshaw, et al., 2002, p. 339)

The next sections will describe in detail parts of the three-dimensional spaces where the teachers are experiencing creation of math PBL curriculum. The rich, thick description will provide context for the actions and decisions the participants make while going through their experiences. Freeman Schools have an elaborate learning model that requires their teachers to use a common learning language and a common planning design. The intricate parts of this learning model are contemplated throughout the individual case studies and later discussed at the end of chapter four as well as in the discussion in chapter five. Understanding the Freeman Schools learning model through a rich, thick description aids the understanding of the analysis process that yields the findings of the experiences of these three participants.

**Table 1**

*The Freeman Schools' Demographics*

<b>School Year 2019-2020</b>	<b>East Campus</b>	<b>West Campus</b>
Grade level	9th - 12th	9th - 12th
Student enrollment	499	479
English as a second language count	11	24

English as a second language PCT	2.2	20.28
Not English as a second language count	488	455
Not English as a second language PCT	97.8	379.72
Individualized education plan count	52	51
Female count	260	248
Male count	239	231
American Indian count	0	1
American Indian PCT	0	0.77
Asian count	50	19
Asian PCT	10.02	16.12
Black African American count	181	335
Black African American PCT	36.27	279.71
Hispanic count	67	44
Hispanic PCT	13.43	36.4
Multi-race count	28	22
Multi-race PCT	5.61	18.65
Pacific Islander count	0	0
Pacific Islander PCT	0	0
White count	173	58
CEP Economically disadvantaged rate	46.81	64.58

**The Freeman Schools.** The Freeman School, an inquiry-driven, project-based high school, was designed through a partnership between a large, northeastern school district, The Emmy Noether Museum, the founding Principal Bell, and district planners. It opened its doors in September 2006 with a pupil-teacher ratio of twenty to one and the percentage of minority

students at sixty-seven percent (Laufenberg & Lehmann, 2012). More than ninety-five percent of the graduates pursue some form of post-secondary education and The Freeman School has won many awards and honors. In September 2013, planners opened a second campus, called The Freeman School West. The two schools serve a total of seven hundred and fifty students, each of whom is issued a laptop for a one-to-one digital learning environment. Admission is by a holistic evaluation that includes an interview conducted by a teacher and student teams (Laufenberg & Lehmann, 2012).

*(Dashboard, 2020)*

### ***The Freeman Schools' Learning Model***

**Pedagogy.** The core values of inquiry, research, collaboration, presentation, and reflection are emphasized in all classes at The Freeman Schools. Drawing on time-tested pedagogical strategies, the school implements the core values with student-centered, project-based and backward-designed curriculum, primarily focused on science, technology, engineering, and math (STEM) subjects (Laufenberg & Lehmann, 2012).

**The Freeman Schools' Common Language.** There are two main purposes of Freeman Schools' use of a common language. First, it helps all learners understand exactly what the school is about, and two, it binds the community together in a shared purpose. The language the students use reveals an authentic engagement with the pedagogy of the school. The way that Freeman Schools talk about teaching and learning reflects a thorough, common vision, and it touches many different pieces of the school. Teachers use the common language so naturally that students absorb it automatically. One example of this is how the core values —Inquiry, Research, Collaboration, Presentation, Reflection —are listed on big posters displayed around the school. They give students a way to talk about their learning. When students are asked to describe a

project they did recently, they can remind themselves of the steps just by cycling through the core values.

**Three essential questions.** “How do we learn? What can we create? What does it mean to lead?”—form the basis of instruction. Students reflect on how they learn and consider their particular learning styles. Students create, which is the basis of project-based learning, and they take a leadership role in their own education. Classrooms reflect the interconnected components of teaching: inquiry-driven, project-based learning, and backward design of the curriculum supported by a one-to-one program. At Freeman Schools, learning is not just something that happens during the school day. It is a continuous process that expands beyond the four walls of the classroom into every facet of a student’s life. How students learn matters as much as what they learn. The inquiry-driven curriculum design ensures that the essential questions lead to relevant, enduring understandings.

**Grade Level Essential Questions.** Each grade cohort is assigned a yearly theme and the essential questions provide inquiry for those themes. Throughout the school year, these themes are then investigated in each content area across the entire school community.

1. Freshman Year Theme: Identity
  - a. Who am I?
  - b. How do I interact with the environment?
  - c. How does the environment affect me?
2. Sophomore Year Theme: Systems
  - a. How are systems created?
  - b. How do systems shape the world?
  - c. What is the role of the individual in systems?



3. Junior Year Theme: Change

- a. What causes systemic and individual change?
- b. What is the role of the individual in creating and sustaining change?
- c. What is the relationship between the self and a changing world?

4. Senior Year Theme: Creation

- a. Seniors are expected to come up with their own essential questions pertaining to their final Capstone Project for graduation.

**Core Values.** Pedagogical strategies are infused in the core value component of the common language.

- 1. Inquiry-driven learning is essentially scientific thinking. Students start by posing a hypothesis, question, problem or scenario to explore. They identify relevant topics to pursue, conduct research, and piece together the solution. Students establish or confirm facts, solve new or existing problems, and develop theories.
- 2. Research is the examination of information to confirm facts and theories and add to existing knowledge. Students explore topics and ideas, sometimes analyzing conflicting data to synthesize and apply their findings as to knowledge in the context of what they knew before.
- 3. Collaboration is teamwork. Students form partnerships to take advantage of one another's skills and resources to build knowledge on a topic. They explore data jointly, share information, discuss their findings, determine relevance, evaluate one another's ideas, monitor each other's efforts, and present what they've learned together.
- 4. Presentation is the demonstration or performance of what students know and are able to do. As they acquire the knowledge about a specific topic or inquiry, they incorporate

thinking about how to apply or present the information so that others will understand it, learn from it, and derive value from it.

5. Reflection is the act of considering an idea carefully and determining its value in a given situation. Students review the ideas and data they encounter and contemplate their value to the problem or inquiry they are exploring. They may find conflicting information and/or ideas that contradict what they hypothesized initially, or data that isn't appropriate to the situation. They have to analyze the information and apply what they think is relevant. In the process, they have to examine how they are evaluating the information to make sure they view it accurately (Laufenberg & Lehmann, 2012).

***Standard Rubric.*** Part of the common language also includes a standard rubric that is used by each content area. The rubric categories are (a) design, (b) knowledge, (c) presentation, and (d) process. These categories are defined as demonstrating an effective design, presenting the knowledge they've acquired, applying the knowledge with specific examples, effective presentation, and following a logical and organized process. Teachers evaluate students on how well they achieve each category based on the criteria that they exceed, meet, approach, or do not meet expectations (Laufenberg & Lehmann, 2012).

**Table 2**

*The Freeman School Rubric*

	Design	Knowledge	Application	Presentation	Process
--	--------	-----------	-------------	--------------	---------

Exceeds expectations					
Meets expectations					
Approaches expectations					
Does not meet expectations					

(Laufenberg & Lehmann, 2012)

***Technology Used in Freeman Schools.*** The one-to-one laptop environment allows students to incorporate a world of knowledge into their projects. It also empowers students to search multiple sources for answers online. Each student is responsible for topic inquiry and, ultimately, the presentation of their findings. Thus, each student has the ability and responsibility to show what he or she knows in the most sophisticated manner possible. The Freeman Schools began their learning model with a one-to-one laptop program. It is essential to the model because they've been using Online Document Application in conjunction with a learning management system (LMS) since 2006. The laptops are a tool for learning. So students carry them around and use them in their classrooms all day. Then they continue learning, working on projects, and doing homework at home with the same laptops. Other types of technology used at the Freeman Schools are smart boards, projectors, tablets, word processing software suites, cloud computing, two kinds of student online information system (SIS) software, online student progress reporting software, and cell phone applications that aid with productivity and compliment PBL

(Laufenberg, & Lehmann, 2012).

**The Freeman Schools Advisory & the Ethic of Care Program.** Advisory is a four-year relationship between a teacher, twenty students, and their parents. The advisory class meets twice per week for 40 minutes. Students are given school-related information and have the opportunity to participate in discussions, exercises and activities that assist them in developing competencies critical to achieving optimal academic and personal success. Advisory ensures that every student in the school has an advocate—one teacher to whom they know they can always go to for help. Advisory programs promote healthy student development, support academic and personal success, and provide the setting to teach and practice important life skills. One of the major goals of the freshman year advisory program is to help ensure each student has a healthy, productive and enjoyable transition to high school. In the upper grades, the advisory program continues to support students' academic and personal development and helps students with their Individual Learning Plans and post-secondary planning (Laufenberg & Lehmann, 2012).

### ***Description of the Content Analysis***

The content for these narrative case studies is the field notes, interviews, and questionnaires. The field notes consist of collected digital data from the participants' work surrounding how they create math PBL curricula and my experience being a founding staff member of Freeman School. The digital data includes all the content collected that participants keep in their Freeman School digital document storage, the Freeman School's LMS, and any online content produced by or about the participant. For example, this could be public blogs and/or publicly recorded video presentation and speeches. My experience consists of intimate knowledge of the learning model and practical knowledge about pieces of process teachers are attending to when creating PBL math curricula.

**Document Analysis Measurement Tools.** The field notes and the interview transcripts are all uploaded and analyzed for themes that will assist in discovering findings to answer my research question: How are public school mathematics teachers—at the Freeman Schools—using project-based methodologies and leveraging existing technological resources in the development of urban school curricula? The codes chosen along with the three-dimensional space analyzation method determine the validity, reliability and inter-rater reliability to reduce errors and bias (Yin, 1989).

To find the themes, the field notes and interviews are coded in the Dedoose software using codes. The codes are consistent organizational units of meaning that are previously defined categories. These categories relate to answering the aforementioned research question. This process also includes the sub-questions from chapter one. The unit themes being analyzed in this study are, (a) how are teachers creating math curriculum, (b) the beliefs and philosophy the participants have pertaining to curriculum creation experiences, and (c) the experiences of the participants are having inside the creation of curriculum process. The categories and themes relating to these units evolve out of the initial analysis of the units.

Using the Dedoose cloud-based software, I was able to do the initial analysis of the participant's relevant data, the field notes, and interviews. Next, I was able to come up with the coding categories: the first category codes, the green ones, are denoted with a "0"; the next cyan level codes are denoted with a number "1"; and my codes cease here at the magenta level, denoted with a number "2".

The codes distinguish meaning from all the relevant data by being further deduced into subsections of the unit themes. For example, the unit theme "how" in this study has two levels of codes under it. Dedoose has a color-coded visualization of these codes built into the software.

Green is at the top of the hierarchy, then cyan, and magenta (see Figure 3). Codes were applied depending on the participant's relevant data content area that was being analyzed at that time. Codes are also added during analyzation if another theme emerges that is significant in explaining how and what the participant is experiencing when creating PBL math curriculum.

Qualtrics questionnaire software was used to create and administer the questionnaires. A digital voice recorder was used to capture interview data that was transcribed into word processing software which was then entered into the Dedoose Software for analysis. This study is qualitative. Therefore, the questionnaires are also thematically coded in the same manner as the rest of the data. The questionnaires do contain Likert scale style questions. However, due to each case study, in this study, consisting of one participant, the Likert scale questions were not used for a quantifiable theme or finding. Rather, the questionnaire Likert style questions were used to frame and pose questions for the semi-structured interviews. These parts of the questionnaires gave me an initial understanding of where each individual participant was in their attitude toward technology and PBL. The questionnaires were a useful tool to challenge some of the initial beliefs the participants had and to confirm some of their other beliefs, all of which I was able to capture narratively.

These narrative case studies have a concise content analysis that adheres to the methodology of the entire study. The content of relevant data was analyzed through Dedoose for thematic findings. This was performed in conjunction with three-dimensional space analysis which influenced the decision-making process around the types of codes to assign while fulfilling the analysis process. The methodology then dictates that the themes and findings born out of the analysis of the content be member checked, thus rounding the cycle of a narrative case study analyzed through three-dimensional space, to ensure validity and ratify any and all

limitations. The analysis cycle I referred to is (a) the contextual beginnings, (b) questioning and inquiring about the individual's experience, (c) the three-dimensional space analysis, (d) content analysis, (e) restorying the individual's experience, (f) discussion of themes from the restorying and content analysis, (g) member-checking and reflexivity, (h) analysis, and back to (a) the contextual beginnings.

**Interviews.** I conducted Four semi-structured interviews over a three-month period. Participants could choose a phone meeting, an in-person meeting, or a remote meeting to conduct these interviews, and all participants chose to do remote meetings via internet video software. I recorded their voices on cell phone software and promptly removed them and put them into a secure folder online. Each of the four interviews lasted between fifty and seventy minutes. The first interview established each participant's positionality and as much of their epistemology that the semi-structured interview time would allow. The second interview followed-up on the last interview and included clarifications from the first questionnaire "Teachers Attitudes Toward Technology." I based the third interview around the second questionnaire given to participants called "Teachers Attitudes Toward Project-Based Learning." Lastly, I structured the fourth and final interview around the triangulation methodology used in narrative inquiry called "member checking" (Clandinin, & Connelly, 2000; Creswell, 2002). I asked each participant to review their transcripts and the analysis I synthesized from their interviews, artifacts, my theoretical framework, and the literature review.

**Interview Space and Procedures.** Each participant was given a choice to meet in person or meet online for an audio and/or video call. The participants chose video and audio calls. The time and remote locations varied for each participant. I was either at home or at my desk at school in front of my computer with headphones recording the interview. On most occasions, the

participants were in their homes during these interviews. Two interviews took place on one of the teachers' prep times and one interview was from the participant's car.

The added value to an interview on a video call is the ability to share screens. One participant was able to show me in detail what artifacts they were referring to as well as how they organize their use of technology inside various software applications.

**Data Triangulation.** I collected two questionnaires, teaching artifacts, and triangulated that data with the four interviews. The final of the four interviews was purposeful and had two goals: one was ethical and in consideration of the relationship of the researcher to the participants. The other was to achieve the type of triangulation that a narrative case study requires in narrative inquiry (Clandinin, & Connelly, 2000; Creswell, 2002; Jick, 1979).

Having adopted this methodology to uncover the answers to my research question, I must be able to discern in my data collection the difference in natural versus manufactured evidence (Dwyer, & Davis, 2016; Silverman, 2013). I have made this distinction and avoided manufactured evidence by triangulating the storied and non-storied data. Analyzing the data in these two defined categories aids in substantiating the answer to the research question and not compromising the methodology in the process (Dwyer, & Davis, 2016; Silverman, 2013). This narrative inquiry is about the stories and is not treated lightly as they both carry and inspire significant obligations and responsibilities: these stories are cared for as they are at the heart of how we make meaning of our experiences of the world (Huber et al, 2013, p. 214). There is no other way to encapsulate the significance of these educator's contributions to the current educational literature than to write their experience out in totality; in relation to the specific conditions that made these schools and the curriculum authored by them a possibility.

**Coding.** I recorded and transcribed the interviews and typed them into word processing



software. I uploaded the transcripts into Dedoose, a software for qualitative analysis. I created codes to look for similarities (things happen the same way), differences (they happen in predictably different ways), frequency (they happen often or seldom), sequence (they happen in a certain order), correspondence (they happen in relation to other activities or events), and causation (one appears to cause another) (Saldaña, 2009). Coding included relational and descriptor comparisons to determine themes within the narrative data. Jones (2015) asserted, “This software system is designed to provide a report of codes that do not fit within the patterns developing during analysis or identify an excerpt that is not coded” (p. 50). After I created the initial codes and applied them to each transcription loaded into the Dedoose software, I reviewed them multiple times in order to create child codes searching each time for themes and interrelation of those themes (Creswell, 2002). I weaved the themes together with the literature, theoretical framework, and the research methodology to interpret larger meanings within the participant’s experiences.

### **Researcher’s Bias and Observer’s Paradox**

Researchers need to be cognizant of several items in order to deliver a study that is as unbiased as humanly possible. Creswell (2002) gave researchers a blueprint that can help prevent the typical pitfalls that occur when attempting a study, such as this one, that contains insider qualitative research. The main idea is that researchers reveal their positionality and engage in reflexivity: “[t]his means that you reflect on your own biases, values, and assumptions and actively write them into the research” (Cresswell 2002, p. 18). This study includes my reflections on personal experiences, my cultural background and possible interpretations/conclusion I can draw in light of my positionality when posing an investigation (Creswell 2002, p. 18) about how public school mathematics teachers create curriculum for urban schools using project-based

methodologies, in a specific learning model, that uses current technological resources.

All parts of this study, including the discussion and the strategies to collect data, are framed within the researcher's bias and the observer's paradox. The formulation of each conclusion is rooted in the lens of the researcher, and each time this could cause a tension in relation to my positionality as it is brought into the context of this study to ensure ethics and integrity in the final discussion in chapter five (Creswell, 2002).

### **Generalizability and Transferability**

It is difficult to make general claims using a narrative case study. The small group sample in my study is not representative of a larger population (Merriam & Tisdell, 2015). However, this study is transferable by the readers as they interpret and make decisions about the "rich, thick descriptions" (Merriam & Tisdell, 2015, p. 257). This study contains a description of the setting and the participants combined with the detailed findings that have adequate evidence presented. This adequate evidence comes from quotes taken from participant interviews, field notes and the documents from the participating teachers (Merriam & Tisdell, 2015, p. 257). Lincoln and Guba (1985) clarified this idea by saying the reader needs to assess the similarities to their situation and the thick description of the context is the best way to ensure the possibility of transferability by the consumer (Lincoln & Guba 1985; Merriam & Tisdell, 2015). Therefore, the reader makes a judgment about generalizability to inform the decisions that will need to be made about the study having enough connections to their situation to accurately transfer meaning for their intended use of the dissertation.

### **Threats to Validity and Reliability**

Qualitative research dives deeply and with great clarity, providing the material that often influences education policy and planning, as well as school leadership and administration. It is

the stories that grip decision-makers and create a desire to write policy and influence educational practice (Bell & Encel, 2013). Clearly, the nineteen-year trend of “data-driven decision making” cannot be disregarded. But the *numbers on a page* approach has steadily been losing ground, ceding influence to the anecdotal stories of success and failure. The stories are driving change, along with the impossible (is impossible what you meant?) metrics of these educational laws.

Growth, skepticism, and new ideas—as well as the onset of the internet and its ability to facilitate the dissemination of the aforementioned —are combining to drive the findings of qualitative research studies to an increasingly growing audience (Lichtman, 2012). This research will be poured over and investigated for validity by all readers (Lichtman, 2012, p. 315), and the researched-mined stories will be grounded in academic ethics and responsibility.

When it comes to qualitative research in education, there are two recurring themes: (a) a tension in the validity of the findings and (b) a lack of a commonly accepted academic definition of what qualitative research is in totality (Burgess & Bryman, 2002; Lichtman, 2012). That said, there is ample evidence that qualitative research has had a notable impact on educational research and it is generally accepted as a useful vehicle for exploring specific settings of education and the elucidation of those settings (Dwyer & Davis, 2016; Lichtman, 2012; Markus, 1997). Dwyer and Davis (2016) contend that a narrative case study is unlikely to adhere to fixed procedures because many authors do not agree on the issue of validity and reliability, and he concludes that “planning and reflexivity replace hard-and-fast rules” (Dwyer & Davis, 2016, p.14). In the following sections, I explain the planning and reflexivity that ensure validity and reliability have been addressed in these narrative case studies.

### **Internal and External Validity**

Creswell (2013) recommended that researchers use at least two strategies in a study to

provide credibility to internal validity. Given that there are not standardized or fixed procedures for the qualitative narrative methodology to cite credibility (Dwyer & Davis, 2016), this study relies on commonly accepted procedures. Member-checking is the first strategy and Glesne (2016) says this strategy is used to make sure the researcher is representing the participants and their ideas accurately by sharing interview transcripts, analytical thoughts by the researcher, and/or the drafts of the final report. Secondly, I clarified the bias that I have as a researcher and discussed openly and honestly these biases that would frame my interpretation and approach to the research findings. Lastly, the members on my doctoral committee are “expert audit[ors]” that serve to assess the quality of the research data analysis and the findings. In regard to external validity of the “rich and thick” (Lincoln & Guba 1985; Merriam & Tisdell, 2015) descriptions of the Freeman School’s settings and participants, I provided details throughout this study to ensure transferability. The cause-and-effect relationships that I analyze in chapter five are generalizable to other persons and settings.

### **Inter-rater Reliability**

Yin (1989) pointed out that “the goal of reliability is to minimize the errors and biases in a study” (p. 45). Triangulation of the data and the findings is how inter-rater reliability is achieved in this study. Each participant had a final interview where they could review my findings and conclusions based on their contributions. This was also the time that participants made corrections to specific perceptions detailed in chapter four and analyzed in chapter five.

The coding rules that I recorded in and with Dedoose ensure inter-rater reliability by keeping my method of analysis transparent to my participants when it came time for them to review their case studies and my findings. I listed and discussed the themes throughout each individual case and their sections in chapter four; this organization aided the ability of the

participants to quickly clarify their understandings of my perceptions of the data. And when participants are rating the study with critiques, comments or notes, they possess insight for the meanings I have applied to each piece of my analysis.

## **The Unit of Study**

### ***Procedures***

1. September 2019, two questionnaires were sent out via Qualtrics, “Teachers and Project-Based Learning” and “Teachers and Technology.”
2. Informed consent was attached to the “Teachers and Project-Based Learning” questionnaire.
3. In September 2019, the participants were selected.
4. I formulated semi-structured interview questions for the epistemology and positionality of the participants.
5. I began the first of four interviews during October 2019.
6. The “Teachers and Project-Based Learning” questionnaire and interview answers were reviewed, and the second semi-structured interview questions were formed.
7. I began the second interviews in November 2019.
8. The “Teachers and Technology” questionnaire and interview answers were reviewed, along with the second interview answers and the third semi-structured interview questions were formed.
9. The third set of interviews took place in late November 2019, early December 2019.
10. During December 2019 and January 2020, teacher artifacts were collected from Freeman School’s Learning Management System and online file sharing applications.
11. I began the analysis and triangulation of the collected data from late December 2019

through February 2020.

12. Final interviews were conducted in mid-February 2020. Final edits applied to chapter four and chapter five based on data triangulation and interpretation by the participants.

## **Schedule**

### ***August-September***

- IRB secured (see Appendix A)
- Informed Consent (see Appendix B) and questionnaires (see Appendix G and H) sent to participants
- Participants selected

### ***October-November, December-January***

- Four interviews held with three participants
- Questionnaires collected and analyzed
- Teaching artifacts collected and analyzed
- Interviews transcribed and analyzed

### ***February and March***

- Final analysis
- Triangulation of results
- Final edits
- Conclusions and future research

## **Informed Consent and Protection of Human Subjects**

Participants opted in and gave their informed consent (see Appendix A) at the beginning of a questionnaire called, “Teachers and Project-Based Learning ”(see Appendix G), using the cloud-based Qualtrix questionnaire software. I wrote the informed consent for this narrative

inquiry with West Chester University's "Informed Consent Form Creator" on West Chester University's website. This generator creates informed consent verbiage at the correct reading level of eighth-grade for participants to read and sign.

### **Summary**

In the above sections, I have detailed the methodology I used in establishing new knowledge surrounding public school mathematics teachers creating curricula for urban schools using project-based methodologies, in a specific learning model, that uses current technological resources. In order to tell the curriculum creation stories of the three participants accurately, and without bias, I adopted the narrative case study methodology, treating each participant as an individual case. There is also an in-depth description of three-dimensional space and how I use it as a lens through which all of the collected data is analyzed in the following chapters.

In the next chapter, I present the data that I organized into "rich, thick" (Merriam & Tisdell, 2015) sections detailing the four individual case studies. I summarize important details from the four interviews I conducted with all three participants and then compare them with each other and the artifacts. I present these artifacts in each participant's section and then I analyze them in chapter five to construct meaning for the purpose of answering my research question.

## **Chapter 4: Results**

### **Introduction**

In this chapter, I present the results from interviewing all three participants and collecting the artifacts related to their stories. I analyze the data using the three-dimensional space approach (Clandinin & Connelly, 2000). In order to answer my research question, I have separated each participant's narrative case into sections to organize and "restory" (Clandinin & Connelly, 2000; Ollerenshaw, et al. 2002) the key elements of their story. These elements can include the time, the place, the plot, and the scene. The idea behind restorying is to casually link the participant's ideas when parts of the sequences are missing and their ideas are not fully actualized. By restorying the researcher can create sections filled with themes and rich details about the context of the participant's experiences (Ollerenshaw, et al. 2002).

### **Case #1- Susan**

Susan has been teaching Algebra 1, Algebra 2, and Geometry, as well as coaching the girls' basketball team, at Freeman School East for ten years and six months. Susan holds advanced degrees from ivy league schools. Susan also is a consultant, a coach, a mentor teacher to student teachers, and an Adjunct Professor. Currently, Susan holds a National Board Certification in Mathematics and a Certification in Secondary Mathematics.

I interviewed Susan on three different occasions (totaling 150 minutes) during the months of November 2019 through February 2020. During the first semi-structured interview, we discussed Susan's demographics and backstory to establish Susan's epistemology and positionality relating to her role as an educator. The first interview took place, in November 2020, remotely on an online video conferencing application, during the evening hours.

I used the second semi-structured interview time to clarify items from interview number



one and discuss Susan's attitudes toward technology. The second interview provided insight into the types of technology Susan uses and how Susan uses that technology at Freeman School. The second and third interviews were held at the same time for Susan because of time constraints. During this same time, Susan explained her attitudes toward PBL and also how Susan creates PBL mathematics curriculum. I conducted this interview from cell phone to cell phone on the evening of December 2020. I conducted the fourth and final semi-structured interview after Susan read over a draft of the dissertation in totality to fulfill the research methodology's requirement of triangulation using narrative "member checking" (Clandinin, & Connelly, 2000; Creswell, 2002). I also conducted the fourth interview remotely on an online video conferencing application during the evening hours in February 2020.

### **Interview One - Backstory and Positionality**

Susan grew up in a suburban upper-middle-class home and attended the schools in her neighborhood catchment area; meaning Susan has had a traditional education. Susan's positionality is centered around this suburban upper-middle-class upbringing. However, she is aware that "...you tend to teach the way that you were taught because that's what's familiar." (Susan Interview 1)

After high school Susan went on to college, although, she did not go directly into a teaching major. Susan says she was meandering toward teaching while trying to actively avoid the profession.

I majored in psychology in college. Wasn't a math major, I wasn't an education major, but after college, went abroad, coached lacrosse, taught phys ed. When I came back, I recognized I really wanted to work with kids. I had been trying not to be a teacher for a long time. And everybody said you would be a great teacher...[a]nd, ultimately, I ended

up being a teacher. (Susan Interview 2)

Susan started with smaller jobs in the northeastern section of the United States and at a private school. She stumbled into her first position in mathematics in a private school because a colleague of hers fell ill. Then, after student teaching to get certified, Susan was hired at the Freeman School. During the interview, Susan reflected on the early days of just being hired at the Freeman School.

I really am, was, and still am passionate about inquiry, about different project-based learning. But when I was much younger or 11 years ago, I had an idea of what that looks like. But I hadn't experienced that at the high school level before. So, you tend to teach the way that you were taught because that's what's familiar. And so, that definitely was a transition. It was definitely very interesting, figuring out how to manage the collaborative aspects of projects because I think that was really challenging. So, I was learning how to teach [collaborative projects]. (Susan Interview 1)

Susan went on to talk about her philosophy, distilling her teaching philosophy down to one sentence. "I really want them to own everything that they do" (Susan Interview 1).

Marcie: "Can you describe your teaching philosophy" (Susan Interview 1)?

Susan: Teaching philosophy, I guess... [the] reason, why I teach, is so that kids can...recognize what their true potential is and figure out what their interests are and basically be a facilitator to get them to that point where one, they can recognize their true

potential, their strengths, weaknesses, and then recognize them [fully]... and not as weaknesses, but areas that they just need to build on and focus on to improve. I want them to do things that are meaningful [in the] now, you know, [the] meaningful now, but also that lead them to...open up and see the connections across curriculum, [and] different courses. I really want them to own everything that they do... I want them to see it as like, not just, you know, oftentimes we see math is, 'here's the answer', but there's more beyond the actual answer. Like, 'is it actually the answer or is it only the answer?' If you have these particular parameters, how can you adjust the parameters such that the answer is different? I'm seeing it as, I don't know, just figuring out how to work or collaborate and play to each other's strengths and weaknesses and help each other out and see it as a community of learners and hopefully helping kids to recognize that they want to continue learning beyond the classroom and that they don't [have to] stop... (Susan Interview 1)

Susan is describing her base philosophy to be a collaborative journey that students go on to find meaning in life through math. And she describes how math can lead to meaning outside of the parameters of a math equation and outside of a math course. Susan believes that making connections and transferring knowledge with people and across disciplines is an important part of having students recognize their true potential in math and as a person.

Susan has participated in presentations on her beliefs about mathematics instruction and these contributions to conferences further describe Susan's positionality and how she views math instruction as a collaborative learning experience. The following is a synopsis of Susan's 2017 discussion in collaboration with three other teachers:

Math can be a polarizing subject for students. By the time they reach middle and high

school courses, many students, particularly students of marginalized populations, have decided that they ‘just aren’t good at math’. Shifting the emphasis from product to process and exploring the value of wrongness in the classroom can encourage students to bring their existing understandings into the classroom to provide a richer experience for all students. We see this shift in mindset as crucial to any math classroom, and we bring perspectives from Freeman School and Urban One to explore this concept. This conversation will focus on the learning processes of student teachers and their mentor teachers, utilizing projects to emphasize both process and final product, and being able to adjust the trajectory of curricula based on the varying comprehensions that students bring into the classroom. (*Embracing Error in Math Class: The Power of Wrongness — Conference 2.8.*, 2016)

There are quotes and passages by Susan in the following narrative sections of the data that reveal Susan’s intentional inclusion of social justice issues in her curriculum creation. Susan presented (with a group of teachers) on this topic with the title “Social Justice by the Numbers: Integrating social justice topics within mathematics courses.” This synopsis, along with the supporting documents, demonstrate to the core of her curricular choices and how she is creating PBL math curricula.

Why are the prices at grocery stores different depending on their location? Is there a pattern to where they are located? Are all groups proportionately represented in the local and federal government? What is the mathematics behind minimum wage and living wage? Join us for a conversation that examines these questions (and more) through a mathematical lens, with a focus on strategies to incorporate social justice activities and

projects into a high school mathematics curriculum. (*Social Justice by the Numbers: Integrating social justice topics within mathematics courses* — Conference 2.7., 2015)

The slides below supplement the presentation and are an example of the through-line that Susan and her colleagues are concerned with as they discuss creating a curriculum. Student choice, collaboration, and reflection are exemplified here, which are three of the factors Susan speaks about during our interviews. I describe these in detail in the next section when Susan relates how student choice, collaboration, and reflection are important considerations she makes when creating curricula.

#### **Figure 4**

*Presentation slide examples from Social Justice by the Numbers presentation*

### **Algebra 2 Project**

- Focused on Probability, Statistics and Data Analysis through a Social Justice lens.
- Students choose a social justice theme that interested them (we suggest possible topics, or they can propose a topic of their own).
- Students then collaborate on a research-based statistical analysis of their topic.

## Algebra 2 Project

### Final Products:

- A formal written report including:
  - A mathematical analysis of the topic from each group member.
  - Visual representations of key data.
  - A “Recommendations for Future Action” section.
- A 2-5 minute video PSA

Conference 2.7 Social Justice by the Numbers. (2020)

As we were ending the interview and Susan was summing up her philosophy of teaching, she did speak to a piece of PBL that makes it difficult for teachers to help students learn while remaining inside of the construct of their professed teaching philosophy.

Susan: ...one of the most challenging parts about project-based learning is, particularly in math, I think there needs to be a fundamental skill set, a base skill set...when we have kids who don't have that, how to adapt it in a way that it's not spoon-feeding what they need, but how do we truly challenge them in a way that is even more meaningful. (Susan Interview 1)

Teachers' philosophies of education are important to recognize since the curriculum they create is the result of their thinking and work. A teacher's mission in education and their general approach to education work is relevant to understanding how the teachers are constructing these curricula over time. I revisit Susan's last comments in detail during the combined second and

third interviews, and again in the second and third case studies. The theme of skills and skill sets surfaces throughout all their cases.

### **Interview Two and Three - Experiences Relating to Technology and PBL**

Susan speaks about how she is creating curricula within three main themes. Susan talks about (a) structural components to her curriculum, (b) student and teacher roles, and (c) teacher research. All of the basic themes are a part of Susan's core beliefs and attitudes toward the Freeman School learning model. The Freeman School learning model is based around PBL, technology and a common learning language. Susan's commentary is based around those three things which reveal her curriculum creation process.

Susan's three main themes are explored during the interviews to create a context for the steps involved in her creation process. Susan distills the structural components of her curriculum creation into six subsections containing: student voice, student choice, expectations, timing, assessments, and student reflection. The categories Susan uses to describe the roles that teachers and students switch in and out of during instructional meeting times are learner, facilitator, coach, and designer. Susan explains the main topic of teacher research through teacher reflections and collegial collaboration, along with resource gathering, creation, and vetting.

Before Susan began describing her three main themes, she explained her definition of PBL. Susan explained her definition by saying, "I think that the PBL model is where we really want kids to discover things more on their own rather than doing the direct instruction and telling them what they should know" (Susan Interview 2 and 3). Susan went on to clarify this by saying:

PBL is something where our kids are able to apply the skills that they've learned in class into a real-world scenario and where there's not necessarily a single open-ended, or, there's not a single answer for every version of a project that a kid does. Whether it's

student A or student B, there are tons of different ways that you could arrive at a solution.  
(Susan Interview 2 and 3)

And, the final two items she added to her definition of PBL were, “...to help kids recognize how they can actually use math in real life... [and] help them to learn how to collaborate with other human beings” (Susan Interview 2 and 3).

The terms ubiquitous or technology-infused are descriptors for the technology used at Freeman School. Students and teachers use laptops and several kinds of cloud-based applications to achieve the above unit’s goals. Within this unit, Susan used an LMS to disperse resources and collect student work. Students and teachers used laptops to communicate ideas and create artifacts, make calculations and conduct research. Susan used Cloud-based word processing suites for the presentation part of the unit to design visual aids full of clear and engaging information. The word ubiquitous completely describes the way Susan used technology in this unit. There is no explicit mention of technology and it is important to recognize that Susan utilized technology throughout the entire unit and in all of her curricula. (Susan Interview 2 and 3)

### **Structural Components of Susan’s Math PBL Curriculum**

Susan constantly thinks about her curriculum so that students can “discover things more on their own rather than doing the direct instruction and telling them what to do.” And to do that she has set up a system of expectations around scaffolding to build skills. She professes, “...with the younger kids, oftentimes it's more structured towards the beginning of the year.” She is doing this by, “set[ing] up systems [for] work periods ...we give them goals at the beginning of each period” (Susan Interview 2 and 3). Susan goes on to explain that the goals are organized by



...instituting checkpoints along the way and documenting [where students are in the project], to “make sure that students can rebound before it's too late.” Susan explains that this is important to teach students “how to manage” when doing PBL lessons.

Structurally, Susan also ensures that there are clear descriptions of the project. She says, “I make sure that they have clear descriptions in order to follow along... [it] is incredibly important to have clear descriptions so that kids have a clear vision of what they're expected to do and what... the ideal outcome is for us” (Susan Interview 2 and 3).

For Susan, there are also larger considerations about PBL expectations as she thinks about and creates her curriculum. She reflects,

I understand sacrificing a little bit so that kids can actually do the project-based stuff. I also want kids to understand if they go from our school to another school, teachers need to make sure that teachers cover most of the topics in algebra one so that when students go to another school, [or] if they move ...they need to be able to do well ... on [any] part of the new school's algebra curriculum. (Susan Interview 2 and 3)

Susan says, at the same time, “teachers try and make sure that we have some mathematical skill foundation upfront so that like nobody gets left behind”. (Susan Interview 2 and 3) She gives more detail on this statement by saying:

...we make sure to have some foundation, like some fundamental mathematical skills before they embark on the project so that they can do the project, and teachers teach them new skills upfront and they learn new skills as we go throughout the project time period ... we make sure that the base [mathematical skill set] is in place first. (Susan Interview 2 and 3)

As Susan explains pre-teaching mathematical skill sets, she is actively reflecting and thinking about what teachers are doing in other classes, if teachers are building skills inside of the PBL units, and/or if they are pre-teaching a set of skills before the PBL unit begins. Susan said:

...and I'm curious about what that looks like in other classes... do the other teachers teach all the skills ahead of time and have the kids do the projects or is this through the process of the project they learn these new skills?" (Susan Interview 2 and 3)

Susan describes how employing student voice and student choice helps with the structure of building in the development of mathematical skills in order for assessments and reflections to flow along with the projects the students are working on. She says that the activities can encourage reflections and she builds this by having her students collaborate while using "a variety of materials in addition to textbooks," in addition to "hands-on and real-life tasks or activities, which involve going outside the classroom". She goes on to explain that:

Students went out and they looked for different patterns, different kinds of geometric elements, you know, like weather patterns, like perpendicular lines, line segments, lots of basic things, ...highlighting what they see on everyday level... looking at tessellations, looking at fractals, different things like that, like what they could find. So, we do like them to go outside. (Susan Interview 2 and 3)

Susan describes how she uses student choice in a project that begins with students creating a survey. "[T]hey had to choose a number of questions that were relevant to the topic

that, you know, [a topic] they held near and dear to their heart and then analyze and create visual representations in terms of graphs” (Susan Interview 2 and 3). She circles back around to describe how this choice then lends itself into a natural order for time management and collaboration. Susan describes how the clear descriptions of the PBL unit help students to make decisions about time management. If students want to “spend more time upfront” to set up the project, they can do so, and then the student groups begin developing roles for collaboration to fit the work into the timing of the PBL unit” (Susan Interview 2 and 3). Susan says, “I like it when the kids assume those different roles too” (Susan Interview 2 and 3).

[And] if one kid is particularly tech-savvy. Awesome, great, the student takes that. If somebody else is more research-oriented and wants to focus on the upfront kind of things, that student takes on that role. If somebody wants to focus on the writing, that student takes on that role and then all of the students have to, across the board ...need to demonstrate each of those math skills embedded into the PBL unit. (Susan Interview 2 and 3)

She explains how this embeds many skills at once to communicate to students the PBL structure. Susan says, “math teachers teach them all: PBL timing skills and mathematical skills, embedded into some of the other parts as we go. In terms of creating a timing that works out well for the students getting the project completed” (Susan Interview 2 and 3).

The final curricular component that Susan relays during her interview was about reflection; reflection for students after a specific PBL unit, and teacher reflection before, during, and after PBL units. Susan says, “I think it's important for both teachers and students to reflect. Teachers have students do our PBL unit reflection at the end of every project” (Susan Interview

2 and 3). Susan says the student reflection structure comes from the Freeman School's common rubric categories of "design, presentation, knowledge, application, and process." Built into the categories are the questions that include:

Do we need to adjust a project midway because something that we anticipated would be okay? What wasn't okay [in the PBL unit]? And then have them talk to me about what they saw and where they think mistakes were. And then we brainstorm and we troubleshoot and think about how could we do it better. I also talked to the students about tech and they give me feedback about [that too]. Um, so yeah, reflection is huge. (Susan Interview 2 and 3)

In regard to teacher reflection, Susan says, "you have to be willing to put yourself out there and fail a couple of times before you get good. I adjusted throughout the lesson [thinking about] why did my students understand that? The scope of the project" (Susan Interview 2 and 3)? And Susan circles back to describe reflecting on the entire PBL unit creation process, beginning with her definition of PBL by saying:

[w]ell, because we [the teachers] had them [the students] talk through it rather than just being told what it was. Right. Um, so, you know, and then we [students and teachers] talk about ways we [students and teachers] can always make it better. (Susan Interview 2 and 3)

The Freeman School Model uses Understanding by Design (UBD) unit planning structures to communicate across content areas and for accountability inside a public-school system that requires teachers to be lesson planning. Below is the social justice UBD that is an integral part of Susan's PBL math curriculum creation. In this example below, Susan's intentional use of the

Freeman School's common language, in the "STAGE 2: Evidence - Evaluative Criteria, Core Values" section is made clear in Susan's curriculum writing process. The "Core Values" common language was introduced in chapter three and Susan's Freeman School UBD- Algebra 2 - Social Justice (see Appendix J) is an example of how the "Core Values" are actively part of Susan's thinking and creation process as she lays out units for PBL math curriculum. "Essential Questions" are another structural component and part of the Freeman School's model surrounding its common language. Again, Susan focuses the lens of the "Essential Questions" common language to reflect the PBL math curriculum that Susan created. This rubric, Freeman School Algebra 2 Rubric Example - Social Justice (see Appendix E) is a specific example of a structural component of Susan's PBL math curriculum and shows the assessment that goes into the social justice unit referenced above. I have included Table 2, The Freeman School Rubric (see Table 2), to compare the Freeman School's model rubric and Susan's interpretation for her social justice unit.

### **Student and Teacher Roles in the Classroom**

Susan explains that when creating her math curriculum, it is important for teachers "to assume the different roles of facilitator, [while] sharing [the roles with the students] of instructor, [and of] learner" (Susan Interview 2 and 3). I asked, "Are you comfortable assuming the different roles that it takes to teach your math PBL units?" (Susan Interview 2 and 3). Susan responded, "Yeah, I like the variety" (Susan Interview 2 and 3).

Susan said as the facilitator there is a ... constant push and pull of how in-depth do you [the teacher] want[s] to go and how much breadth and depth [should be incorporated into one math PBL unit]. In regard to creating a math PBL unit that will be successful facilitated Susan says, "we actually have to look forward to making sure that they [the

students] can find something [relating to the unit on the internet] (Susan Interview 2 and 3). This previous comment incorporates her ideas about the structure of scaffolding her PBL math units and she supports the comment by saying “if we want them to explore data and pricing on alternate types of energy like ‘more green [energy]’, like sustainable energy” (Susan Interview 2 and 3). Pre-researching the available online mathematical resources for successful facilitation is part of Susan’s process when creating new curricula. Susan goes through the unit as if she were the student, in search an appropriate amount of mathematical information online, in order to complete the computations relating to the unit she is creating and later will have to facilitate.

Susan talks about her role as a learner and a designer when she discusses how she uses technology to create her PBL math units. She says she likes to be able to “produce high-quality examples or show them [the students] and it helps to be a better learner and designer by collaborating with her colleagues” (Susan Interview 2 and 3). Susan said, “I don’t know that I was super confident with tech until I got to Freeman School” (Susan Interview 2 and 3). For over ten years Susan has been immersed in a one-to-one laptop environment and tasked with the daily use of smart boards, projectors, printers and various kinds of software. Susan expressed that “having time to explore and having time to collaborate with colleagues and talk through different programs they’ve used and what they’ve seen” has helped and helps Susan feel confident with the technology, and the different roles she takes on within PBL. Susan also explained that “having access to a computer at home has allowed me to play with things so that I can feel good about it when I’m in front of the kids” (Susan Interview 2 and 3).

Susan explains that when creating her math curriculum, it is important for teachers “to assume the different roles of facilitator, [while] sharing [the roles with the students] of

instructor, [and of] learner. I asked, “Are you comfortable assuming the different roles that it takes to teach your math PBL units?” (Susan Interview 2 and 3). Susan responded, “Yeah, I like the variety.” (Susan Interview 2 and 3)

Susan said as the facilitator, there is a “constant push and pull of how in-depth do you [the teacher] want[s] to go and how much breadth and depth [should be incorporated into one math PBL unit]” (Susan Interview 2 and 3). In regard to creating a math PBL unit that will be successfully facilitated, Susan says, “We actually have to look forward to making sure that they [the students] can find something [relating to the unit on the internet]” (Susan Interview 2 and 3).

#### **Interview Four - Member Checking**

The final interview for Case Study #2 - Susan was held in the late evening on Thursday, February 27th. This was a semi-structured interview with the purpose of member checking (Clandinin, & Connelly, 2000; Creswell, 2002). Susan had prepared for the interview by reading the chapters and her case study. When we spoke, I front-loaded the conversation with an explanation of my findings and how the methodology works in the limitations section of chapter five. And lastly, I told her about the application of my conceptual framework to the findings and the discussion for future research.

#### **Susan’s Perceptions and Observations - In Her Words**

***Susan’s Experience.*** Susan spoke about her experience in terms of an action —the action of unit planning. Susan reiterated that the act of successful facilitation and pre-scanning the internet is the experience she repeats for two reasons. One, for the assurance of successful facilitation and, two, she is also researching current mathematical skills that are relevant for her high school students. Susan speaks of this experience in terms of backward designing units and inquiry. She is asking herself questions as she is creating the curricula:

I guess I like really engaging in the backward design planning. What are the end goals that you want kids to get out of the unit and how do you design it in a way that you can achieve those goals, those larger overarching goals and then what are some of the skills that you would like to cover in this particular unit? In terms of math, we have tons of standards that we need to look at based on NCTM, which is the national council of teachers of mathematics. And then also what Freeman School teachers decided on or the certain standards we apply to our courses. So, those are some of the guiding things.

(Susan Interview 4)

Susan stopped herself there and regrouped her thoughts about her exact experience. Above she is speaking about the goals of the design when experiencing curriculum building and her next thought centered around the space she is experiencing all of this in. Susan says:

But how do we actually do it? I don't really ever sit down and plan a unit by myself. I have, but I think it's way easier and way more effective and so much better when I can plan it with other people, my colleagues, because they're great and smart and thoughtful and have ideas that are not the same as mine (Susan Interview 4).

This detail about the collaboration component to her curriculum creation is important to recognize because it relates to the three-dimensional space of her experience and also shows how teachers are experiencing the core values that are a foundational structure to the Freeman School Learning Model. Here she speaks to the exact process, that process of assured successful facilitation and how the lived experience of the unit day today with the students is not always inside the true definition of PBL:



I think that when we take a unit and we plan it, kind of, just like look on the internet and scan for ideas, you know, like, well here are all the skills. What are some of the projects? What are some of the activities? I like to start off the unit with something fun and exciting and inquiry-driven course. And then sometimes you just, even though it's project-based, you know, some days are not as project-based as others and you're going to be okay with that. You also gotta be okay with the fact that things are going to often take longer than you expect because if you want the kids to actually understand where they come from and how to do it, it's not just giving them information in them, regurgitating it, but it's actually them figuring out how to do it on their own. (Susan Interview 4)

Susan is revisiting her ideas about skill-building and how her PBL curriculum does not always match her teaching philosophy. She is making the point that there has to be room in the experience of creating math curriculum for more traditional processes of skill-building. These are the ideas and I informed her that is a tension in her experience. Susan has a curricular conflict which she explains in her own words in the next section.

**Curricular Conflict.** When Susan and I ended the first interview, she talked about the experience she has had as a math teacher where she feels a responsibility to teach discrete math skills, which pulls her away from her professed teaching philosophy that is centered around PBL. And this school year, Susan is dealing with increased pressure in preparing her units and filling them with adequate math skills experiences for her students. Susan is being confronted with the loss of instructional time on top of 2020 being the first year that senior high school students, in her state, will have to take a standardized test to earn their diplomas. She explains:

... we lost several instructional days. And then realizing ... our scope and sequence and comparing where I normally am compared to where we are at this year, we're probably a month behind almost because of that, like the three different resets that we've had to do or the two different resets that we've had to do plus the loss of instructional time. And as a result, I don't think my students are as well prepared as they normally would be for the graduation standardized test ... I was trying to think of what would prepare them for actually taking an exam. (Susan Interview 4)

Susan's conflict is an abrupt reality for her this year that she is trying to reconcile adequately preparing her students for a standardized test and teaching the curriculum she has created. She explains the way that she knows how to prepare students and she says:

Well, how do you prepare for an exam? You get prepared to take an exam by taking an exam ...being familiar with more of the types of questions that are going to be asked. Like multiple choice. We don't do that ever in class. But they need to be good enough to eliminate options that they know are wrong. And so mastering this like demonstrating mastery of the [math skills] that we have explored in class rather than focusing on the [math] that they don't know. (Susan Interview 4)

Susan, an ivy league graduate, knows what it takes to be competitive and she is struggling with the reality of having to prepare her students and augment the curriculum that is written out of her philosophy of teaching. She personally knows the skills her students will need to “master” in order to get passing scores, however, she goes on to justify her reaction to this pressure by saying:

... regardless of whether or not we're a project-based school, everything that they need to do after high school, will involve them having to take some kind of standardized tests. If they want to go to grad school, they have to take the GRE for a lot of schools. If they want to go to business school, they have the GMAT. If they want to go to law school, they have the LSAT. If they want to go to med school, they have the EMCAT ... And I don't necessarily believe that exams show how much kids know or how well they can apply their skills. But at the end of the day, if they can't do well enough on exams, they're not going to get to the point where they're allowed to apply their skills in more complex ways that they want to do. (Susan Interview 4)

The pressure Susan is experiencing this year is amplified evidence of what math teachers are experiencing when confronted with the curricular conflict to teach discrete skills or to create mathematical experiences that will enable students to authentically build the necessary math skills to remain competitive on standardized tests.

**Susan's Iterative Process.** When Susan explains her experiences with revisiting her curriculum and editing it, she consistently stresses the reflective voices of her students, and that this editing process is a collaboration. Susan brings up an interesting anecdote to begin explaining her experience with the iterative process when creating curriculum.

[When] I first started ... at Freeman, I looked at the projects that had been done in the past and I noticed that a lot of the projects weren't really project-based learning. They were longer assignments that kids were asked to do and they seem project[based] because they were longer and they were asking them to do things with design and presentation. But ultimately some of the projects had a single answer or one correct

solution. (Susan Interview 4)

Susan believed that this curriculum did not honor what she conceives is PBL. And she says, “we changed them over time and every year we've reflected.” Susan insists that “it [is] more meaningful because students have increased choice and, with this increased choice,, they're able to own the project more than they would if I said here's the project” (Susan Interview 2 and 3)

Susan is experiencing collaborative and reflective practices with her students and her colleagues as she changes and refines the math curriculum for Freeman School East. Susan is simultaneously experiencing the Freeman School learning model as she works out the iterations of the curricula with her students and colleagues. Susan is in a recurrent pattern of inquiry, research, collaboration, presentation, and reflection. Susan says:

And I often find that when there's a good comment made [from the reflection process] or like [the teachers] come up with an idea, I just go to the doc and I make a comment, ‘here's some suggestions for next year’, make the suggestions in the unit plan about potential projects that we might want to do in the future, in the coming years. I would say, like, a lot of it happens right after the project's done. And depending upon how the end of the year finishes out, you know, if we're given time in our PD,it's a great opportunity to really think about what worked well this year and what [you] didn't like and what are some of the things that we want to do differently. And one of the things I wanted to do differently this year; that definitely. (Susan Interview 2 and 3)

Susan explains she solicited feedback from her students in either a formal reflection

and/or passing comments when the students are asked to answer questions like:

Did you like how we facilitated the work periods? Did we provide enough feedback? Did you like this as an individual project? Did you like the collaborative components? Did you, and we ask them a lot of questions, again and again, then at the end of the year, we remind them what the projects were and what the tasks were. And then we ask them to reflect again now that they've had all of the year to really think about, well, how did I grow as a student in a project-based environment? (Susan Interview 2 and 3)

Then all this feedback goes into her decision-making process about how to or not to restructure her curriculum for the following year. Susan's experience is to constantly be thinking about and improving upon her curricula inside of the Freeman learning model, and in collaboration with her colleagues and students.

### **Case #2 - Kim**

Kim has been teaching Algebra 1, Calculus, and Geometry at Freeman School West for five years and six months. Kim is a graduate of a northeaster private college, earning a Bachelor's in Arts for Mathematics and Sociology. She then attended an ivy league university, earning a Masters of Education for Secondary Education and Teaching in the content area of Mathematics. Kim has a teaching certificate for Secondary Mathematics.

I interviewed Kim four different times (totaling 143 minutes) from November of 2019 through February of 2020. During the first semi-structured interview, we discussed Kim's demographics and backstory to establish Kim's epistemology and positionality in regard to being an educator. The first interview took place in November of 2020 and was conducted remotely on an online video conferencing application, during the morning hours.

I used the second semi-structured interview to clarify items from interview number one and discuss Kim's attitudes toward technology. The second interview provided insight into the types of technology Kim uses and how Kim uses that technology at Freeman School. I conducted the second interview remotely on an online video conferencing application, during the evening and morning hours, in December of 2020.

During the third interview, Kim explained her attitudes toward PBL and how she creates PBL mathematics curriculum. Kim also helped clarify items from interview number two at this time. I conducted this interview remotely on an online video conferencing application during the morning hours in January of 2020.

The fourth and final open-ended interview occurred after Kim read over a draft of the dissertation in totality to fulfill the research methodology's requirement of triangulation used in narrative "member checking" (Clandinin, & Connelly, 2000; Creswell, 2002). The fourth interview also took place on an online video conferencing application during the evening hours, in February of 2020, and I recorded it remotely.

### **Interview One - Backstory, Demographics, and Positionality**

Kim grew up in an upper middle-class environment in a school where she was recognized for being gifted in math. Kim is a humble person who recounts this memory with duality. On the positive side, Kim felt singled out in a good way for being smart and, on the negative side, she wonders if this type of recognition set her up for failure as she later realized that the approach toward higher math concepts at the college level proved to be completely different than that of her memorization training in high school. Kim remembers:

I was one of those students that got pulled out to go to a special math class, because I was, I guess, more advanced in math. But then, I always think about how that kind of set

me up later because when you're told when you're nine that you're really, really bright. And now I'm in a math class with three students and of course I then understood material and was challenged and it was a problem-solving type of method because, you know, again, we were considered advanced so we could go really deep into concepts and we, we drove that instruction because there were three of us. (Kim Interview 1)

Kim goes on to talk about getting into college and finding out that in traditional education setting, being the “smartest” did not set her up for an easy transition into college mathematics. Kim says,

I only knew how to do problems if a teacher had done one just like it. And I was very good at memorizing ... [it was a] huge struggle for me, my beginning of my college, really challenging for me ... I think because now [in college] I was introduced to a different type of math where students or teachers were not giving me answers ... I wasn't a good problem solver and I always thought I was great at math. I did very well on my SATs because I just did a hundred practice problems... (Kim Interview 1)

This childhood and young adult experience forms Kim's positionality, but she did not consider teaching as a career until her last year in college. Kim explains,

I feel like it was really late on in my college career that I even thought about pursuing teaching in until then I was a volunteer ... I started volunteering at an adult education program for adults who wanted to get their GDS. Um, they were mostly immigrants or just students who had dropped out of high school for whatever reason ... I liked interactions with people and I was really passionate about the material and it just seemed

like a fit for me. So not until, I would say it was, my senior year of college [did I consider teaching] until then had before just kind of been something that I was doing as like a side gig. I started volunteering at an adult education program for adults who wanted to get their GEDs. It was there I really found a passion for teaching, and I decided to apply to [a northeastern college] that had a teacher education program. This was a one-year program after undergrad that gets you your master's and your teaching certification. And while there I was placed at Freeman School East center to do my student teaching. So, I student taught under Susan, and was there for a year. Really loved the model and they had an opening at their Freeman School's West campus. So, I applied and took that position. So, I've been here now, this is my sixth year. (Kim Interview 1)

Kim says she feels like she got a late start in her career. However, after realizing she had a “passion” for teaching, she enrolled in a master's course that included a teaching certification and has been in a classroom of her own inside of two years. Kim also explains that she did her student teaching with the participant in Case Study #1; Susan. This is important because of the timeline that Kim later describes from being immersed in a PBL environment. Kim has now been in her own classroom for almost six years and in her next two interviews she explains how that experience and her beginning experiences at Freeman School East has shaped her positionality and her epistemology when it comes to PBL mathematics curriculum.

### **Interview Two - Experiences Relating to Technology**

Kim is very adept at explaining her experience relating to technology and to PBL. However, the nuance to what she describes about her experience and practice could be lost without careful attention to her positionality and her epistemology. I call attention to this because



these are the two things that finally give Kim, as she explains, the confidence to create curriculum and set boundaries for technology in her curriculum. Kim explains:

... out of all of our departments, I probably use technology the least ... a graphing calculator and those online resources can be super valuable once those students have those discrete skills that come from paper and pencil. So it's important that technology doesn't become a crutch for them, right? We forget how to do things on [our] own, but [technology] becomes a resource for them [in my class]. And there's just some insane visualizations that we can do on computers. So that I think there is the benefit to using technology when it can create visuals for us so that we can then have a better understanding of concepts. But at least, in my classroom, technology is not driving instruction ... and I think there is, in some ways, a need for students to be doing paper and pencil type of things in math because I think that it actually helps with their reasoning. (Kim Interview 2)

Kim's experience with technology pushes her toward a low-tech classroom. She believes in "intimate conversations with students" to "push them along" where it is needed. Kim elaborates, "reflections would pretty much be the only time that computers needed unless we are looking up assignments or watching mathematical video simulations." And Kim adds, I do use the technology for "administrative types of things, grades, and our LMS."

Kim's explanation in this section builds toward how she uses what she believes to be the true definition of PBL, to create her math curriculum. Kim gives detail in the next section about what influences her creation process and how her curricular conflict is resolved by adherence to her PBL philosophy.

### **Interview Three - Experiences Relating to PBL**

Kim laments that memorization was her early mathematical experience. And this is the experience that influences her when creating curriculum. Kim describes:

... it wasn't until college, as a math major, that I finally was understanding how to think that way. Up until then I'd been kind of taught like, what to think and then here it is and now let's just do it again. In college, I was finally being tested on how I can use what I know and then show it in a way that makes sense. (Kim Interview 2)

When Kim says “how to think this way,” she is referring to critical thinking and problem solving. It is this experience that guides her curriculum development and slightly rebellious actions when it comes to standardized tests. Kim attests,

I think it drives my instruction in a way that I don't want students to go to college without having that experience. I pushed them much earlier on to try and solve problems that I haven't showed them how to solve yet. So even when we think about what we proved and we now know how to apply it, then the next day we walk in and there's a problem on the board that's going to involve the Pythagorean theorem. But I don't outright tell them that... So, that type of instructional teaching I think makes them exposed to it sooner. Like, let's think back to what we already know and now what, how, what can I use to do that? But then I also just tell them, you know, some of this stuff takes years. We're building you to be a mathematical student for years and you're going to get better at it over time. It's okay that you're not great at it right now. (Kim Interview 2)

**Figure 5***Examples of Kim's Curriculum*

<b>Goals:</b> <ul style="list-style-type: none"> <li>How and why do we <u>write</u>, <u>simplify</u>, <u>evaluate</u>, and <u>solve</u> algebraic equations/expressions?</li> </ul>	
<b>Unit Essential Questions:</b> <ul style="list-style-type: none"> <li>What are algebraic expressions &amp; why use them?</li> <li>What are equations? What does it mean to "solve for a variable?"</li> <li>What does "simplifying" mean in math? Why do it?</li> <li>Is the correct mathematical answer to an equation always the best solution?</li> <li>When does solving for a variable find use in the real world?</li> </ul>	<b>Understandings:</b> <i>Students will understand that...</i> <ul style="list-style-type: none"> <li>Algebraic statements provide a systematic and precise way to capture and understand some life situations..</li> <li>The value of a variable can only be determined if the variable is isolated.</li> <li>Simplifying helps us make sense of solution and have more concise justifications.</li> <li>Correct mathematical solutions may not mean the best solutions.</li> <li>There are a variety of contexts where solving for a variable is useful</li> </ul>
<b>Students will know . . .</b> <ul style="list-style-type: none"> <li>Rules for <b>simplifying expressions</b> by adding, subtracting, multiplying, and dividing.</li> <li>Equation as a consisting of a pair of <b>equivalent expressions</b>.</li> <li>Key vocabulary related to the concepts <b>opposite, reciprocal, inverse operation</b>.</li> <li>The meaning of <b>isolating a variable</b>.</li> </ul>	<b>Students will be able to...</b> <ul style="list-style-type: none"> <li>Use the Distributive Property and explain what it means in applied contexts.</li> <li>Apply Properties of Operations and explain what they mean.</li> <li>Identify and write equivalent expressions.</li> <li>Use opposite, reciprocal, and inverse operations to solve for a variable.</li> <li>Simplify expressions correctly:             <ul style="list-style-type: none"> <li>Multiply</li> <li>Add/Subtract</li> <li>Dividing by a monomial</li> </ul> </li> <li>Evaluate expressions.</li> </ul>

*Note.* This shows Kim's curriculum scaffolding towards critical thinking and problem solving within a mathematical computation lens.

Kim learns from this push and pull and adjusts her curriculum based on her experiences. Kim remembers feeling let down, so she reacts with a curriculum that she believes will serve her students as they matriculate into higher education. In addition, as students move through the state requirements inside the public-school district that Freeman Schools belongs to, Kim has a

reaction to a district standardized mandate:

I'm not going to give up instructional time for this. So, I ended up pushing back so much that they did it during advisory instead of during math class because I was really against it being during math class. I didn't see the value of it, but my other coworkers were laughing cause they're like, we're so used to doing things that don't matter all the time because we have been at different schools or they were in a different district and that's just how it is. It's refreshing, I think, for them to hear me questioning things. (Kim Interview 2)

Kim mentions advisory as the place where the students take this standardized test. Advisory is explained in detail in chapter two. Advisory is a four-year relationship between a teacher, twenty students, and their parents. The advisory class meets twice per week for 40 minutes (Laufenberg, & Lehmann, 2012). From a curricular standpoint, Kim felt conflicted regarding the pressure she experienced to get more time for student skill-building toward critical thinking through a mathematical lens. As a result of feeling this pressure and deciding the district test had little perceived value, she became resistant and kept the standardized test out of her classroom.

I asked Kim, “Can you pinpoint a time where you started actually writing that kind of stuff into your curriculum?” I wanted her to expand on why student skill-building toward critical thinking through a mathematical lens was so important to her. I also wanted her to revisit her experience and timeline with regard to growing comfortable with teaching in the PBL model. This next passage reveals an important part to her experience.

I would say, I think year one I was very hesitant. Year one, I thought I needed to show

my students how to do every problem and then they'll be able to do every problem. And I will say, having students taught in the Freeman model, I think pushed me back from that more than maybe I would have even in the first place. Which was good! I was really fortunate to grow up in that model. But the part where I personally started explicitly writing into my curriculum, those types of things --I think was probably not until year three or four where you feel confident in your abilities as a teacher ... I just find these types of skills are the key to being a math student, I think it is about problem solving. I mean that is really what we're teaching. (Kim Interview 2)

Here Kim describes the timeline that I alluded to in the previous section. Kim “grew up” in the Freeman model and it took her three years to fully grasp the PBL through iterations of her curriculum moving away from showing her students how to do every problem. (not clear what you are trying to say in previous sentence) This part of her experience is telling, especially when viewed through the comparative lens of how other teachers are creating math PBL curriculum. Math PBL curriculum creation takes time. It takes iterations and Kim’s experience in this process reveals insight to how long it takes to create curriculum in a PBL model, even with previous student teaching experience in the same exact model.

**Figure 6***Example of Kim's Curriculum Planning*

Teachers: <b>Kim</b>		Adapted from <b>Freeman East - Kim</b>	
Algebra 1 UbD Unit 3 - Intro to Expressions and Equations			
<b>Goal:</b> <ul style="list-style-type: none"><li>• Students will be able to <u>write, simplify, evaluate, and solve</u> algebraic equations/expressions</li><li>• Students will understand when and why we use equations to solve problems.</li></ul>		<b>Unit Essential Questions:</b> <ul style="list-style-type: none"><li>• What are algebraic expressions &amp; why use them?</li><li>• What are equations? What does it mean to "solve for a variable?"</li><li>• What does "simplifying" mean in math? Why do it?</li><li>• Is the correct mathematical answer to an equation always the best solution?</li><li>• When does solving for a variable find use in the real world?</li></ul>	
<b>Understandings:</b> <i>Students will understand that...</i> <ul style="list-style-type: none"><li>• Algebraic statements provide a systematic and precise way to capture and understand some life situations..</li><li>• The value of a variable can only be determined if the variable is isolated.</li><li>• Simplifying helps us make sense of solution and have more concise justifications.</li><li>• Correct mathematical solutions may not mean the best solutions.</li><li>• There are a variety of contexts where solving for a variable is useful</li></ul>		<b>Students will know . . .</b> <ul style="list-style-type: none"><li>• Rules for <b>simplifying expressions</b> by adding, subtracting, multiplying, and dividing.</li><li>• Equation as a consisting of a pair of <b>equivalent expressions</b>.</li><li>• Key vocabulary related to the concepts <b>opposite, reciprocal, inverse operation</b>.</li><li>• The meaning of <b>isolating a variable</b>.</li></ul>	
<b>Students will be able to...</b> <ul style="list-style-type: none"><li>• Use the Distributive Property and explain what it means in applied contexts.</li><li>• Apply Properties of Operations and explain what they mean.</li><li>• Identify and write equivalent expressions.</li><li>• Use opposite, reciprocal, and inverse operations to solve for a variable.</li><li>• Simplify expressions correctly.</li><li>• Evaluate expressions.</li><li>• Solve one-step, two-step, and multi-step equations in one variable.</li></ul>		<b>Performance Tasks:</b> <ul style="list-style-type: none"><li>• Standards-based assessments</li><li>• Problem sets</li><li>• Multiple Small Group Classwork Assignments</li><li>• Daily Warm-up Problems</li><li>• Benchmark Project: Budget proposal and solving for a variable</li></ul>	

*Note.* This shows Kim's "growing up" from Freeman East to Freeman West. This document shows that it was adapted from Susan's curriculum

**Interview Four - Member Checking**

This is a busy time for teachers, so Kim and I did the "member-checking" via email. I sent her chapters one through five of the study and she read them over. After having read the

chapters, Kim felt the need to clarify her statements about standardized testing. I think she was confused that I did not mention the test by name and wanted to make sure the benchmark style varieties of standardized test were not to be confused with graduation requirement standardized tests. Kim had this to say:

One thing I would just clarify is the standardized testing piece... I did not want to give up instructional time for the students to actually take the [benchmark] test during my class period. We do spend some time reviewing and preparing for the [Graduation] exam in my class, but it is not the major focal point. Most of that preparation instead is given as homework assignments through “Study Island” (an online educational tool). (Kim Interview 4)

The researcher in me was extremely excited to get this correspondence. I then wrote back to her and said, “Excellent, can you elaborate on that? What are your thoughts and feelings about giving up instructional time to prep for the Graduation test, especially in relation to your philosophy of teaching?”

Kim wrote back a thoughtful and sophisticated answer to my question. Kim expounded: I think that the balance between the Graduation Test prep in a project-based, inquiry-driven learning model is probably one of the hardest challenges of being an educator in this school. While we do not put a huge emphasis on testing--we are more concerned with students' individual growth as learners and know that the scores do not account for many of the demographics and experiences of our individuals--the state currently ties the Graduation Test Proficiency to students' diplomas and transcripts. (Kim Interview 4)

In the next part of Kim's answer, she describes how she collaborates with colleagues to mitigate and balance the standardized test, skill building, and other issues the public-school math teachers face. Kim goes on to say: (indent below)

The way that I have personally grappled with this conflict is through conversations with my department and administration. Since the beginning of our school, we have established that this would not be our main focus in Math. As previously stated, we want students to be problem solvers, not just memorizing the formulaic way to solve a problem. However, we still want students to feel validated in their math abilities and to not develop a fear of math based on poor scores. I have found the balance for me as an educator, then, by recommending and preparing students in a variety of ways.

We still try and cover most of the standards addressed on the Graduation test, but [we do this] through an inquiry-based approach in the classroom. Classwork is typically group-based through investigations. (Kim Interview 4)

In the last part of Kim's response to my question she laments about the standardized testing issue, and then explains why it is possible for her to stay positive.

It's not a perfect system, but it's the way I, as an educator, have best struck a balance between wanting students to do well on state testing but also still focusing on the things [that our] department holds dear to mathematics: problem-based, critical thinking and applying their knowledge to various scenarios. The support of my department and administration have also been key to developing and feeling supported in this approach. (Kim Interview 4)



This passage by Kim cuts to the core of what public school PBL mathematics teachers are experiencing. Kim is committed to her philosophy of teaching. She explains how her colleagues and administrators are also committed to maintaining a PBL ethos in their learning community. And with all of this support and a total commitment to PBL, she is finding space to justify non-PBL style instruction. This curriculum conflict is strong in teachers of math PBL and, as Kim explains, it is the tension in keeping a balance between the Graduation Test prep and the philosophy of a project-based, inquiry-driven learning model that makes it a constant challenge to be an educator in this learning model.

### **Case #3 - Adam**

Adam has been teaching Engineering at Freeman School East for five years and seven months. Adam is a graduate with a Bachelor of Science in Mechanical Engineering and a Master's of Science in Mechanical Engineering. He graduated from a top-rated engineering university to earn his certificate in Secondary Education and Teaching. Adam has a teaching certificate for CTE Engineering and Physics.

I interviewed Adam four different times (totaling 245 minutes) from November of 2019 through February of 2020. During the first semi-structured interview, we discussed Adam's demographics and backstory to establish Adam's epistemology and positionality in regard to being an educator. The first interview took place in November of 2019 and was conducted remotely on an online video conferencing application, during the afternoon hours. The second semi-structured interview time was used to clarify items from interview number one and discuss Adam's attitudes toward technology. The second interview provided insight into the types of technology Adam uses and how Adam uses that technology at Freeman School. The second interview was conducted remotely on an online video conferencing application, during the

evening hours, in December of 2019

During the third interview, Adam explained his attitudes toward PBL and also how he creates PBL mathematics curriculum. Adam also helped clarify items from interview number two at this time. I conducted this interview remotely on an online video conferencing application, during the afternoon hours, in January of 2020.

The fourth and final semi-structured interview occurred after Adam read over a draft of the dissertation in totality to fulfill the research methodology's requirement of triangulation using in narrative "member checking" (Clandinin, & Connelly, 2000, Creswell, 2002). The fourth interview also took place and was recorded remotely on an online video conferencing application, during the evening hours, in late February and early March of 2020. This interview was done in two parts. The second part was over a recorded phone call.

### ***Interview One - Backstory, Demographics, and Positionality***

Adam grew up in an urban blue-collar neighborhood. He had a large family and was the first to go to college.

I am a product of a Northeast [section of a large American city] where every single person's father worked in the factory. And every mother, everybody's mother was a homemaker and it was the sixties and everything was in black and white... I never knew any person that had ever gone to college. I had sixteen cousins. None of them had gone to college. I didn't know anything about those things. (Adam Interview 1)

Adam is self-deprecating when he speaks about his early education. Adam said, "I was a bad student the whole time because I didn't study, I never did any homework or anything." It was in his high school physics class, with a teacher Adam can still recall, that Adam found his reason

to become a serious student. Adam described the exact moment:

...and he walked up to the blackboard on day one and started teaching me physics and I was like, this is it. The world has opened to me. I understand how the universe works. And I said this is what I'm going to do.

Adam did go to college for physics and switched his major to mechanical engineering before graduating. After college Adam worked in the NASA Space Program for eight years. When he left NASA, he and a friend went on to build a “software development consulting firm” (Adam Interview 1) and he built/ran that for twenty-five years. Adam sold the firm in 2012 and, being a young retired person, started thinking about his second career.

...and one night I was lying in bed and I was thinking about what I wanted to do with the rest of my life and it suddenly hit me, teaching. I could teach, I could teach high school physics. And that idea so consumed me that I couldn't sleep, and it's all I thought about every night lying in bed was teaching. I went through, what's my [class]room going to look like and how am I going to teach [the students]? Who am I going to be in that room and what are the kids, how are they going to relate to me? And it consumed me. And I said, well that's it. So, I quit my job and I became a teacher. (Adam Interview 1)

Adam explained that, at the age of fifty-three, he enrolled himself into a teacher residency program and began student teaching at Freeman School. Near the end of his time studying under the school's physics teacher, a teaching position in Engineering opened up and he seized the opportunity. This is how Adam came to teach at Freeman School East.

When I began to move the semi-structured interview questions from Adam's background

to his positionality as a teacher and what PBL is to him, Adam began by relating:

...the vast majority of people that I speak with are not steeped in our philosophy of project-based learning ...the thing to do is to contrast it to what they know. So I say, you know, I, I don't assess my kids based on tests. I assess them based on what they can do, not what they can regurgitate. And part of what they can do is solve problems and design products in my realm. Right. And can you solve problems and can you design products? And that's what I assess [the students] on. (Adam Interview 1)

Adam goes on to explain to me his view on PBL and relates it back to my content area of art in order to help me to understand his train of thought:

...project-based learning is very, very well suited to match up with engineering, right? Uh, between you and me, right? Art, teaching art and teaching engineering is all about projects and making things and doing things and working with your hands and all of that stuff. And, so, it's a natural fit. (Adam Interview 1)

Next Adam begins talking about his beliefs around being a classroom teacher and how he enjoys pointing out to students that mathematics does not get practiced in one specific classroom or one part of a person's life. Adam says:

...it's not about me. It's not about this persona. It's not about who I am, it's about [the students]. And, so I have to reign in my narcissism and egotism, which I, it's not raging, but it's there and, instead, make it always about them. And it can't be the cult of my personality ...it's important that it always be about them ...it's not my idea that's driving the classroom forward ...it's their opinion about their own work that's being done ... and

when they see me enjoying them and them enjoying me, then we can start building relationships that are meaningful. And then through those meaningful relationships, we can get some work done. (Adam Interview 1)

After Adam established trust with his students, Adam says he was able to dive into harder concepts in his classroom and ask his students to see math from a different angle and start talking to them about his concept of a “full toolbox. He says to his students, “...you want to solve problems, you want to design products, if you want to, you're going to need to know math because you have to have a full toolbox.” Adam then tells me an anecdote that frames the trust and the “full toolbox” (Adam Interview 1).

And so, very often, [math] comes up in ways to where I'm not actually expecting it because it's how, it's just a tool in my toolbox, right? Like this year I went to solve my first free body diagram ...and all of a sudden I was deep into algebra two and the kids are like, ‘holy cow’ ...he just solved the real problem. They need to trig on top of it. And I just went over three years of math and then I related to the fourth year in calculus and how they could solve with calc and I give that to them as an example of [math is] just another tool in the toolbox and if you want to solve real problems, [students need to] reflect on their mind, and how it is compartmentalizing [math], I say to stop doing that to the students ...and what a fun thing to be able to teach. Like free your mind. (Adam Interview 1)

Adam is saying his joy in teaching comes from his philosophy of teaching. He develops trusting relationships so he and his students can have hard conversations about math that will

inspire the students to try and it will also enlighten them about how the math doesn't live in one place in school, or in design. Adam wants his students to know that math is part of their "toolbox," the "toolbox" that they will need to do all kinds of things in their lives, especially to "solve problems and design products." (Adam Interview 1)

## **Interview Two - Experiences Relating to Technology**

On Monday, November 11, Adam and I spoke again to conduct the second semi-structured interview. I organized the questions for this interview around the questionnaire – Teacher's Attitudes Toward Technology (see Appendix G) and the answers Adam chose and wrote into his responses. I used the questionnaire for a specific topic interview starter and also to loosely guide Adam into related topics about his use of technology while experiencing his math PBL curricula creation process.

Getting teachers at Freeman Schools to talk about technology is an interesting task for an interviewer. The laptops and other technologies are completely embedded in every part of what teachers and students do at Freeman Schools. And, as I tried to get Adam to talk about how he is creating mathematics curricula through the lens of technology, the further he got away from talking about precise uses and would instead talk about his philosophy toward technology. Adam was precise when he explained his personal technological uses and how he sets up his computer and other tools to assist him with what he views as his shortcomings with organization and recall. Adam documents almost everything that occurs in his life with fidelity. He uses voice recordings to capture items he does not have time to write down and then meticulously organizes his voice recordings and notes in a matrix for recall and reflection purposes. Adam uses keywords and calendaring hierarchies to virtually replicate his brain in his laptop and phone. This kind of organization is transferred to the record-keeping of and for his curricula. Adam

carefully curates his planning from year to year and every iteration is documented which is later reflected upon for the following year.

When Adam first verbalizes his thoughts about technology in his experience of creating curricula, he says:

I use technology just like I would a hammer ...I use the engineer's definition of technology, which is like any tool. And, so, you know, technology includes hammers ...for me, learning objectives rarely have to do with learning a particular technology. And it's just like, I don't have a learning objective called use a hammer, but I do have a learning objective. Learn how to envision an invention, be able to design it and then to fabricate it. And I would view any software tool or technical tool in the same with the same lens, which is I teach it to them because I need, they need to understand it to be able to get the thing done, which is really the real learning objective. (Adam Interview 2)

Adam's experience with managing, teaching, and working with technology all stem from this philosophy. To Adam, any tool is a technology (an engineer's perspective). In the next part, he explains his skepticism of technology and ultimately that he needs it to act as a vehicle for learning.

I've always been skeptical about technology, so, therefore, oddly enough I always approach it from the standpoint of proof, 'Hey, technology, prove to me that you're worth the cycles that it would take for me to master you. Fundamentally, how can you help me do the thing that I want to do? And because you're just a tool, I'm just never gonna I'm just not the kind of guy who will pick up a piece of technology cause it's, oh this is so cool.' (Adam Interview 2)

This skepticism is his vetting system. For him to invest time in a technology for himself and for his classroom, the technology needs to have clear worth and significance to the mission of learning. As Adam unpacks this idea, he starts to talk about language being a technology and explains that math is a language for clarity

...language is a tool and tools are technology. And so, I use language to influence, to express what, how I'm thinking and feeling and to communicate that to others. And also, I use it as a persuasive tool. Right. And so, and I try to have my students understand how to use language ... so I'm going to use the language in front of my kids that will be most effective in helping them to change and to learn ... when I teach there's a lot of technical language I need to use and more and that I need to imbue them with, to move into their understanding and to have them internalize. So, I do that little trick all the time. So, I'm introducing large, more sophisticated words that they will know, and then I'll redefine it twice or three times as I'm talking. And it's subtle and it's how you acquire language is in the context. And language, again adds to clarity of thought and for them a major learning outcome is, is developing the skills of clarity of thought. Math is great for clarity of thought because you can express, for instance, relationships between entities very clearly and demonstrably and completely through mathematical language. And that's its inherent beauty, how complete it is and clear. So, we teach them the skills in mathematics. We teach them the skills of being able to utilize and express that clarity. (Adam Interview 2)

Adam is cognizant of controlling the technology (all forms of it) he chooses to bring into



his curriculum designing. Adam meticulously reflects on the “to what end?” question and his experience in answering that question as he builds out the components to his curricula. Adam expands on this by layering his ideas about language being a technology that can be used to explain the models in his curriculum. And in his experience, math is a critical part of this explanatory language that, in his view, should not be compartmentalized. Adam expounds:

... math is the language of how the universe works, right? I mean, the reality of nature can be expressed mathematically and um, and science can be expressed mathematically at its base level. We use that when we develop a model of something, which is usually the place that math becomes practical is when we're using it to model something. And, um, and engineering where the rubber meets the road. I mean, it's all about that, right? [W]hen we build models and solve them or make a design of something and then improve it or analyze it, math is yet another tool and it's THE tool, so I want them to just not view it as a separate subject. I don't want them to view it as, ‘Oh, this is the math part of the problem.’ No, it's all the math part of it, you know, and don't get hung up behind whether we're doing math or we're modeling what we're doing, solving re-optimization or we're doing, you know, it's all just one thing. And of course, you have to be good at math. If you're an accountant, if you're good at, if you're, if you're going to be a race car driver, you have to be good at math. If you're going to a design perspective, drawings, right? You have to be good at math to do all of those things, some version of math is in all of it.

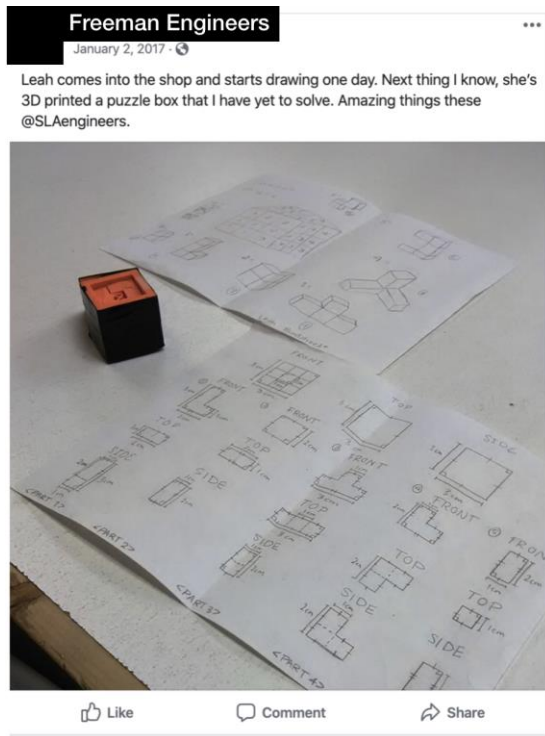
(Adam Interview 2)

The math, Adam says, helps to make what the students are creating make sense to everyone. This is an example of math in service of creation in Adam’s classroom from his

Freeman School East's Engineering Facebook page.

## Figure 8

Example of math in service of creation



Large City, P., & service, E. (2020)

Adam philosophically finalizes this course of thought by saying: (adjust paragraph below)

I just don't want them to view math as being anything separate. I don't want them to view technology as being separate from nature. I don't want them to miss the joy of life in the continuum of all that. How it's all interconnected and that I want them to live it.

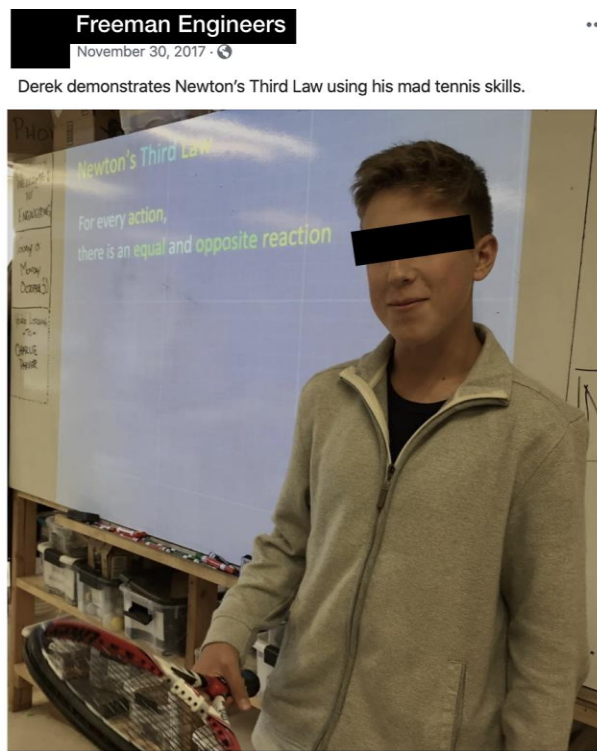
Adam is explaining breaking down the walls of silo-ed content areas. It is important to note that Adams feels strongly about his experience with compartmentalized content areas being a part of his student's presuppositions about where and how math

should be done. Next, Adam describes his experience about how he transfers his philosophical interpretation of technology into the act of creating PBL units.

Adam exemplifies this philosophy, of math being alive in all parts of life, on his Engineering Facebook page. Here a student is explaining Newton's Third Law through his experiences with the Law in the student's tennis practice. (Adam Interview 2)

**Figure 9**

*Newton's Third Law through tennis*



Large City, P., & service, E. (2020)

### **Interview Three - Experiences Relating to PBL**

Five main themes emerged when I asked Adam about his experiences with writing the PBL curriculum. Adam speaks about his role as a facilitator and designer of curricula, the structures inherent in the process of creating curricula, and student skills and assessments. Adam says when he begins to think of all the parts that go into creating his curriculum, he often thinks

about how:

I have to design a whole raft of assessments and it's usually actually in the assessment that I come up with a project. I have the learning outcomes and I can think about what project I want ... then I have to ask the question, but how do I really know that each individual kid is learning the things I want them to learn? (Adam Interview 3)

Adam's experience revealed that assessment leads to the creation of projects and Adam decided which skills he wants his students to come away with after a project is complete. This procedure is the catalyst for his curriculum design process. In the next section, Adam describes, in his own words, what a teacher's role as facilitator and designer is from his experiences.

**Teacher as Facilitator and Designer.** Adam begins by reflecting on the past summer when he had time to reinvent and create curriculum. Adam ruminates on the outcomes of his curricula. He frames his outcomes in the construct of backward design, glances at them in a matrix, then reflects on them as he walks in the woods. This leads Adam to the structure of his ideas and organizing the chosen outcomes into daily lessons and assessments.

This process of thinking and rethinking and redesigning reoccurred for Adam and I asked him, "how important are those do-overs" (Adam Interview 3) And Adam continued with:

Oh, God, super important because what I tried to do is when I'm teaching it, I'm making notes to myself [about] here's my learnings from this unit. Here's my learnings from this day and all that gets captured [in my matrix]. So, when I come around and visit the unit again, I'll very often spend summers redesigning my next thing and I'm reading through all my learning. This summer I sat and thought about what I want to teach. And I put it on a huge matrix of potential learning outcomes. Then I started thinking about what projects

would hit the most learning objectives and because it's project-based, what project and then related to that project is what's the driving question? So this summer I was designing my senior engineering course... 'how can I as an individual student have an impact on a big problem?' (Adam Interview 3)

Adam goes on to explain his process. He puts all the important learning outcomes in a matrix, thinks them through, and then goes for a hike in the woods, seeking inspiration.

... I think about what my resources are against that, what my constraints are. All of those things are like themes all the way through engineering. And then the thing that, you know, the big learning outcome that I have under that is this idea of taking the physical reality of something and building a model of it and then solving the model

On that hike, Adam came up with an idea surrounding global warming and the...

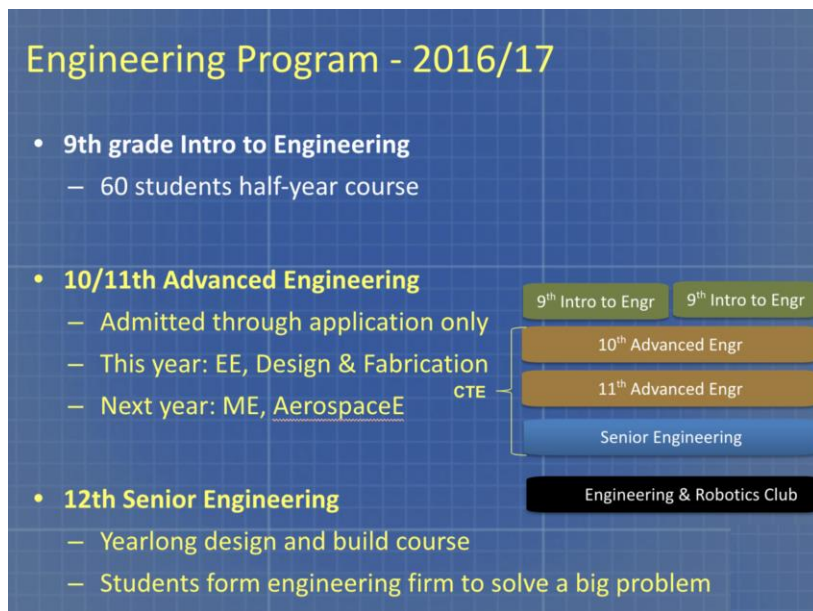
... generational problem of global warming. And so in climate change we spent almost the whole year focusing on climate change and so I laid out a curriculum where we would study it for a month or two, each kid becoming an expert in a different aspect of climate change, and then presenting that their expertise back to other students. And then, looking at what the outcomes of climate change are going on in global warming. And then what would that mean to me as a person, an individual person. I always try to make their learning, you know, relatable to them as individuals as I can ... so two months of work is to ask the question, 'well, how can I as an individual have an impact on such a big problem?' (Adam Interview 3)

Figure 7, below, is a slide from in Adam's digital archives. This slide shows how his

students move through the curriculum he is creating.

**Figure 7**

*Adam's Student Curriculum Map at Freeman School East*



*Note.* This slide shows the path students in Freeman School East move through from one year to the next in experiencing Adam's curriculum. These courses represent all the curriculums that Adam cycles through the iteration process.

**Structures in PBL.** Adam evokes the Freeman School's learning model common language as he describes his experiences with PBL structures. Adam's experiences with structure in PBL are most identifiable when he speaks about Freeman School's UBD template, Freeman School's grade-level essential questions, design thinking while creating curriculum, and reflection.

**The UBD template and grade-level essential questions.** Adam expounds:

... the place where you can see [the structure of PBL] visually is in the UBD template ...

the template (see Appendix L) that we've developed at Freeman specifically requires the teacher to think through not only the learning outcomes of a given unit and how they're going to be assessed in there and for what are the lessons and activities by day. I mean, that's a standard UBD item, but our, um, our UBD templates also come with how does this relate to the themes by grade, right? And how does it relate to the essential questions by grade and how does it relate to the core values? (see Table 4) And they're specifically in their sections [in the template for] inquiry and research and collaboration ... it continues when I'm designing, all of that stuff gets put into a big boiling roiling pot and it bubbles around for a while. (Adam Interview 3)

Adam refers to the Freeman School's UBD template as a place where teachers start to visualize their curriculum. He also adds two notable comments to explain the structure and establish his experience. He says that the Freeman School's template adds in the grade-level themes and already established essential questions that go with the grade-level theme. Adam also points out this is where the iteration starts. He says, "... that stuff gets put into a big boiling roiling pot and it bubbles around for a while" (Adam Interview 3). The "stuff" is the combination of his vision of the project he is writing about in the UBD template, and the grade-level themed essential questions. Next, Adam explains the Freeman School's "core values" (see Table 4) and his experience with how this part of the structure relates to his content area. This excerpt is from a talk Adam gave in Washington D.C. for a consortium of experts that work for free to help solve critical national issues that aid the public and the federal government.

This figure is an example of how Adam creates his curriculum. The top pane is a further explanation of what he is doing to create his curriculum. The bottom pane depicts how Adam

writes up a formal UBD. This is an excerpt from Adam's Introduction to Engineering UBD (see Appendix L).

**Figure 10**

*Juxtaposition of curricular examples to formal UBD documentation*

**Introduction to Engineering - 9th grade**

**Enduring Understandings**

- The made world is **highly designed**
- The **form** of a designed object **follows its function**
- Brainstorming** well is based on a set of **best practices**
- The **engineering design process** is **universal** to problem solving
- You will **always fail** during engineering in the beginning
- Good engineers **fail quickly** and **learn from their failures**
- Engineering is an **iterative** process - **fast iterations** are the key
- Engineers **build on the work of others** - **research** is essential
- A design or solution is **meaningless unless communicated well**

Diagram illustrating the Engineering Design Process:

- Inquiry
- Reflection
- Research
- Presentation
- Collaboration

Illustration of two students working on a project, one holding a tool and the other using a ruler.



Students will understand that:	Essential Questions:
<ul style="list-style-type: none"> <li>• Safety is paramount in the shop and safety procedures must be followed at all times</li> <li>• The made world is highly designed</li> <li>• The form of a designed object follows its function</li> <li>• Brainstorming well is based on a set of best practices</li> </ul>	<ol style="list-style-type: none"> <li>1. In what ways are engineering and science similar and different?</li> <li>2. How can we know how well the form of an object follows its function?</li> <li>3. Why is the engineering design process cyclical?</li> <li>4. In what ways do engineers utilize the knowledge embedded in the designs of nature?</li> <li>4. How do engineers communicate their designs?</li> </ol>
<ul style="list-style-type: none"> <li>• The engineering design process is universal to problem solving</li> <li>• You should expect to fail during engineering in the beginning</li> <li>• Good engineers fail quickly and learn from their failures</li> <li>• Engineering is an iterative process - fast iterations are the key</li> <li>• Engineers build on the work of others - research is essential</li> <li>• A design or solution is meaningless unless communicated well</li> </ul>	<ol style="list-style-type: none"> <li>5. What makes a team function well?</li> <li>6. How do makers actively assure safety when using shop tools?</li> </ol>
Transfer:	SLA-Wide Essential Questions:
<ul style="list-style-type: none"> <li>• Effective collaboration is an essential element in most fields of work</li> <li>• The engineering design process is applicable to many problem-solving situations</li> <li>• Successful execution of a design requires care and quality, regardless of the field</li> <li>• Failing is a constructive part of design</li> </ul>	<p><u>Identity</u>  How does the design of a natural or made object affect me?  What about me informs my design work?  What is my role in the work group, and how does my makeup impact the way I collaborate?</p>

*Design thinking while creating curriculum.* Adam explains:

Freeman founded, with these five core values, one inquiry: being able to ask the questions. So, this aligns really super well with, you know, scientific method and a lot of the conversation we've had, but this is infused throughout the entire school. Once we have that understanding, we focus a lot on presentation. I'll talk about how engineers can present in meaningful ways and then we reflect how we did, what was that process about and how could we improve it in the future? (Adam Interview 3)

Adam identifies that the structure of PBL he experiences is the one Freeman School developed and Adam relates that his content area of Engineering conveniently meshes with this structure. This is important to note because what Adam talks about next is the experience over

time that he went through in order to begin combining his content area with the Freeman School's UBD template.

... the first year and a half was every night, what am I going to teach them tomorrow?

Then, you know at some point I took everything that I had been doing, refactored it probably in year three after that, and now spend a summer making this a lot more sensible and building on each other and [refining] the laddering of curriculum that you need to do as a teacher. (Adam Interview 3)

Adam states that it is at year three when he starts to scaffold and reflect deeply about his curriculum creation process. It is important to note when, in his experience, creating curriculum, he was able to start a deep reflection process to organize his curricula. Adam recognizes that he has starts and stops on a growth experience timeline that occur from being immersed in a PBL environment.

**Reflection.** Adam told me that reflection is an “actionable item”, something that is important to him. Adam explains:

... reflection, for me, it's all about self-improvement is all about how do I continue, you know, continual personal improvement? How can I learn from what I just did and improve next time I do it, you know, um, I'm very action-oriented with reflection?...did I learn, how could I improve it in the future? (Adam Interview 3)

Adam explains his experience with reflection with his curriculum writing usually waits until the summer. Adam says this is because,

I very often don't have enough time to get to it when I'm live, which is the ten months of

the year that I am teaching. Um, and so what I try to do is document as I go as much as I can and then I leave my summers for the deeper thought and reflection and recreation.

(Adam Interview 3)

### **Student Skills and Assessment**

Adam is very clear about the skills he wants students to come away with. This is explained above through the outcomes written into his curricula. However, Adam describes a curriculum conflict that happens in his mind when he builds assessments into his curriculum. Adam has a philosophical commitment to teaching in the PBL model. At the same time, being a product of a competitive collegiate program, the realities of what his students will face as they matriculate into higher education gives him pause as he is writing curricula. Adam explains:

Well, I think most people would look at it and say it's a very progressive way that I assess kids because it's project-based and they have individual expressions related to that. But at the same time, I am the only teacher at Freeman that gives midterms. I have one coming Tuesday, which has a completely different purpose. The reason that I do the midterm is because a lot of them are going to go into one of the toughest majors in college and I want them to be prepared for their midterms and their finals and not wash out. That's another piece of it ... the colleges don't teach right; you have to be ready for things that are not the best way that people do things. And so, for them to get through the little hole that colleges want to squeeze them through, they have to learn how to memorize, how to study, how to memorize a whole bunch of stuff, how to work through problem sets, how to solve things without calculators. (Adam Interview 3)

Adam knows his students will be confronted with these challenges, and he wants to

prepare them. Adam is pointing out the dichotomy between progressive PBL institutions and the tradition of higher education institutions. Adam maintains that the experience of this dichotomy is the cause of his deviation from his philosophy of teaching. Adam is actively creating a curriculum where his students experience traditional methods of teaching. Adam does this, even when he does not agree with the methodology because he believes this experience will deliver his students from having to feel the brunt of traditional methods of learning without any warning.

#### **Interview Four - Member Checking**

The fourth and final interview with Adam was cut into two sessions. Adam had read through the first three chapters and the sections of four and five that were complete. During this first part of interview four, I did most of the talking. Adam had read through the material and I explained what was still missing and what conclusion I was drawing in the final stages of writing. Adam agreed that my perceptions of him were correct in the restorying of his experiences creating math PBL curriculum.

Adam was excited to share added data for me and explained,

I just discovered that I don't know if I mentioned that I spoke to the national Academy of the sciences in Washington around next gen science standards. Yeah. Somebody stumbled over and sent me the link. My presentation lasted for 15 or 20 minutes, I believe there are some good quotes in there. (Adam Interview 4)

This presentation by Adam (2017) did prove to have some great information in it. This video is a concise overview of the case setting and how Adam is creating curriculum for PBL. I did use a quote from this video in the interview three section.

Adam and I connected one final time via a phone conversation to finalize his approval

and for me to ask one last time if there are any misconceptions in my writing and also if he would like to change anything. Humorously, Adam added, please take out all the “likes” and “ums”, he said he was unaware that I would be quoting him so exactly. We both found this funny because neither of us had any experience with participant interview reports, and we learned that conversational language does not transfer intelligently to formal written texts. We had a laugh over this fact. Taking out the “likes” and “ums” was my final editing order from Adam and I proceeded with those changes immediately. We thanked each other and I told Adam it is an honor to tell his story and he let me know that he was honored to be written about. And then Adam hung up to attend his Robotics club. (Adam Interview 4)

This section concludes the restorying of the participants' coded interview data. Next, I explain the specific results of this data to prepare for the final discussion in chapter five.

## **Results**

### **Questionnaire**

In this section I explain how the two questionnaires, “Teachers and Technology” and “Teachers and Progress-Based Learning,” were used for this study. I will also present the information yielded from the questionnaires about the participants.

When I began this study, I wanted an anchor for the semi-structured interviews. I searched for surveys that matched my topic. In reviewing what has been written concerning mathematics, PBL, and technology (as it relates to mathematics PBL), the literature repeated the themes of beliefs and attitudes. I looked for surveys that would quickly get to what my participants believed about technology and about PBL. I found two surveys (see Appendix G and H) and asked the authors for permission to use these surveys in my research (see Appendix E and

F). The “Teachers and Technology” questionnaire came from Brown’s (2014) “Teachers Attitudes and Confidence in Technology Integration” and the *Teachers and Progress-Based Learning* questionnaire came from Petersen’s (2008) *Project-based learning through the eyes of teachers and students: Investigating opinions of PBL in adult ESL*. I updated both of them and, because I have three participants, the surveys become questionnaires.

Table 5 shows a comparison of the participant’s demographic information. It is interesting to note that Susan, who has the most years teaching and the most hours in front of students, has the least amount of planning hours.

**Table 5**

*Participant Demographic Comparison*

	Degree	Years of Teaching	Hrs./week Teaching	Currently Teaching	Hrs/week Planning
<b>Susan</b>	Undergraduate in Psychology, Master’s in Physical Education, Masters in Secondary Education	11-15	35	9-11 Algebra, Geometry	15
<b>Kim</b>	B.A. in Mathematics, Master’s in Education	0-5	21	9-12 Algebra, Geometry, Calculus	18

<b>Adam</b>	BSME, MSME (Mechanical Engineering)	6-10	20	9-12 Engineering	20
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*Note.* Susan is the participant with the most years teaching and the most hours in front of students and the least hours spent planning.

### **PBL Creation Experience Commonalities**

Susan, Kim, and Adam have many things in common because they are teaching under the same learning model. Within the curricular commonalities, three themes emerged through the analyzation of the participant's data: (a) curriculum conflicts in skill-building, (b) the application of iterative design thinking by the participants, and (c) structures inherent to project-based learning. I will explain what these are in terms of my findings and describe each participant's perspective in relation to the themes.

***Curriculum Conflict.*** A curriculum conflict happens for the participants when they experience a tension within their philosophical beliefs toward PBL. The participants described an urgency to teach mathematical skills because of the exterior pressures surrounding standardized testing. All three participants grappled with student skill-building toward a mathematical standardized test versus student skill-building toward critical thinking through a mathematical lens.

Adam believes math is in everything his students do and that competitive engineering schools would pass over students that do not possess discrete math testing skills. Adam does employ a traditional style curriculum of a midterm and testing skills to alleviate the pressure he feels in this curricular conflict.

Susan's approach to skill building has a timely seriousness because her students will need to pass a standardized test to receive a diploma from their district. Susan feels rushed to get

her students the skills they need to pass the test, which for her means teaching the skills traditionally and moving away from PBL. Susan's experience in this regard is pressure.

Kim has the opposite approach; she fends off standardized tests to open up more time for her critical thinking math curriculum. Her experience was to feel let down when she got to higher education math courses, as her talent for memorization did not serve her in her higher-level math courses. Kim felt like she had to learn an entirely new approach to math at a college level. This experience is one of the factors that drives Kim's decision-making process when creating her curriculum.

All three participants believe they are externally rated by the recorded statistical achievement levels relating to the all the math standardized test scores taken by their students. The participants also know their learning communities are judged by these scores because scores are publicly posted for this exact reason. Kim says,

I talk really openly about what we're doing all the time and I think that that's really valuable in a lot of ways. I think it influences our students. I think it influences anyone that's within the district who knows that there are these options out here for schools. And I think Freeman School has created a name for itself. People know what we're doing. But I think the value in our school also is that it's creating a counter narrative to what urban education looks like. (Kim Interview 2)

Kim wants the learning model at Freeman Schools to be understood despite what the standardized tests scores are recording. She sees value in how she is creating curriculum and she wants other people to see that value too.

And because these participants are high school teachers, they are particularly bothered by



knowing that standardized test scores are the deciding factor for where students can or will be accepted to matriculate after high school.

Susan, Adam, and Kim are living the experience of being math teachers in a data-driven decision-making era. The pressure to create statistically successful math PBL units is felt in most, if not all, of their curricular decisions.

**Iterations.** This pressure felt by the participants is a factor in their continuous curriculum iterations. However, it is not the only reason why they reflect on and make adjustments to their curriculum. For instance, Susan is always saying to herself, “how could we do it better” (Susan Interview 2 and 3). And Kim shares the same sentiment, as she said, “We talk about ways we can always make it better” (Kim Interview 2). And Adam, while he pours over his notes and his unit planning “matrix”, asks himself, “How can I learn from what I just did and improve next time I do it” (Adam Interview 3)?

Susan and Kim talk about iterations and redesigning with colleagues and students. The two of them are making these gradual curriculum changes during common planning time and longer group professional development times. Adam is making notes as he goes, checking-in with kids and colleagues, and adding that to his notes as well. He is in a perpetual mode of iterative design. Adam goes from notes to iteration, to archiving (which he calls capturing), and this process keeps cycling. Adam told me he will, “often spend summers redesigning my next thing and I’m reading through all my learning” (Adam Interview 3). Each participant also spoke about “what works” and “what didn’t work well”. They are all on high alert for these things so they can edit their curriculum. Adam pointed out that,

... it's an especially heavy lift early on and you go into a kind of haunting phase and you

refine, and you throw out what doesn't work. The most important learning part I think I get is what's going to connect with kids. And early on, I didn't always know and now I have a higher hit rate now of knowing what's going to connect with kids. (Adam Interview 3)

Adam explains that, early in the career of a teacher creating PBL, the iteration process is a lot of work, but it is also the time to make the most changes. Adam centers those iterations around what he believes will connect with his students. Adam also added that “You have to have discipline about what it is that I really want them to learn” (Adam Interview 3). The last part of his iteration process is to add resources and ways for students to extend projects, or adding in extra ways to access the content of his curriculum.

Susan does not always wait until the end of a unit to make edits to her existing curriculum. Susan said, “Do we need to adjust a project midway because something that we anticipated would be okay and it just wasn't” (Susan Interview 2 and 3) Susan asks herself questions during her cycle iterations process. She thinks through the parts of her curriculum by asking, “What works really well? Why did my students understand that? What is the true scope of the project” (Susan Interview 2 and 3)? She says then she discusses ideas with her colleagues in the math department as well. Susan is making notes for her iterations and then continues a second cycle of iterations with her colleagues in their curriculum planning meetings.

Kim has this same kind of experience with iterations that Susan does and Kim explains it

as follows: “we start having those conversations and explicitly writing that out for ourselves, then I need to be aware of what I'm teaching my students and how I'm teaching my students” (Kim Interview 2). Kim has an added reason for collaborating on iterations of curriculum. She and her colleagues are building on math concepts from class to class as their students move through the four grades. This could look like linear skill building; however, Kim is careful to explain that for her and her colleagues, this is about concepts in math.

Kim explained this process through an anecdote about a recent project she is planning with a colleague. It is important to note here that, like Adam, Kim comments on how involved the work of creating math curriculum is for teachers. Kim explains,

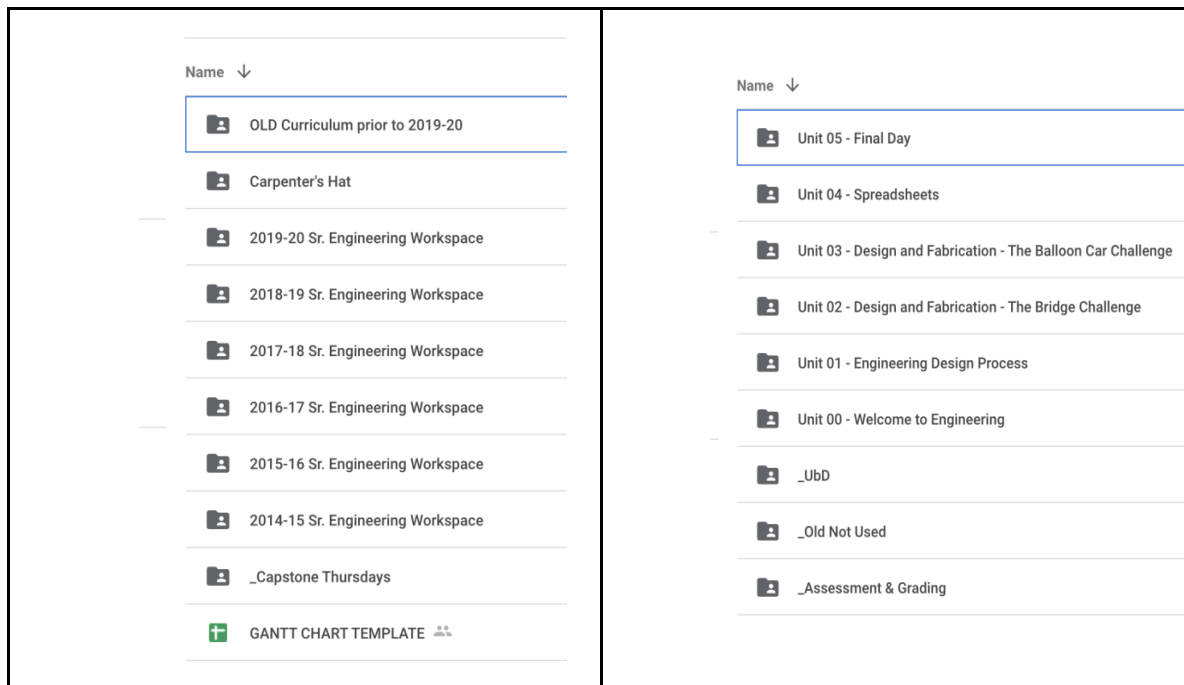
... right now my coworker and I are working on creating a project for our calculus class. We've been working on it for days. It takes a long time to create a new project and we keep going a step back to say, ‘okay, what is the purpose of this project? What are they trying to show us? ‘Always questioning the evidence learning piece, and having adults that you bounce that off of, I think this is really important to creation of this type of curriculum. (Kim Interview 2)

The participants are using words like “heavy lift” and “it takes a long time.” I make a note about that here in the iterations section because as I contemplate iterations as findings in this study about how teachers are creating curriculum, I am asking myself at the same time, how is this different from traditional education curriculum planning? The part that does make it

different is that students in PBL have the burden of evidencing their learning and the participants are explaining what it takes to create a curriculum that lets students show what they know about math. This is why they iterate and refine constantly. The participants are looking for the most interesting way for students to evidence their learning that includes the most student choice/voice. Their iteration process is what helps to get their curriculum to the best version of showing the learning during the student experience as the student works through the project. At the same time, the participants are factoring in assessments, assessments that do not test.

**Figure 11**

*Examples of iterations in digital documents*



### Reliability, Generalizability, and Validity

This study is transferable by the readers as they interpret and make decisions about the “rich, thick descriptions” (Merriam & Tisdell, 2015, p. 257). The “rich, thick” descriptions are the details that convey reliability from the study to the reader. The descriptions detail the items in the content analysis, which are (a) my field notes, (b) the interviews, and (c) the questionnaires. Part of the field notes include my positionality and reflexivity as an insider collaborating with insiders (Herr & Anderson, 2005). My experience as a founding staff member directly influences the conclusions of this study. My positionality is important to note because it could influence the reader’s opinion on the generalizability of the study.

The validity of this narrative case study is upheld in the methodology. I achieved content analysis and triangulation of the data through member-checking and reflexivity (Dwyer, 2016; Glesne, 2016). By member-checking the findings the participants became the inter-raters for the reliability of the analysis of the data.

When analyzing the participants' digital data and comparing it to the content of the interviews, I did not find contradictions from one to the other. The participants also reviewed the digital data I pulled to support their interviews and none of the participants disagreed with how the digital data supported their oral contributions.

I minimized errors and biases (Yin, 1989) by maintaining clear coding rules. Fidelity in regard to the coding rules gives the participants insight about the meanings I have applied to each piece of my analysis of the content.

### **Summary**

In this chapter, I have presented the collected analyzed data using the three-dimensional space approach, regarding teacher lore (Clandinin & Connelly, 2000). I have restored and member-checked my results in order to answer my research question: how are public school mathematics teachers (teaching at the Freeman School, a school that uses current technological resources) creating curricula for urban schools using project-based methodologies? The findings revealed three themes about math teacher curriculum conflicts in skill-building, application of iterative design thinking, and structures inherent to project-based learning. I have causally linked these themes with the participant's ideas that are rich with details about the context of the participant's experiences (Ollerenshaw, et al. 2002).

In chapter five I will present my findings narratively and answer the aforementioned question, along with the sub-questions in this study. I will present the findings in direct relation to the themes revealed in this chapter and I will support these findings with the analyzed data from this chapter.

## **Chapter 5: Discussion**

### **Introduction**

During the summer of 2006, Freeman School’s founding staff gathered to get to know one other and to begin setting the foundation for the school’s learning model. I was fortunate to be among this group of ten educators. All the newly hired teachers sat around tables that formed a U-shape and, using the Socratic Method, the founding principal —a representative from the then partnership museum and an education consultant —began asking questions to begin our week-long discussion. As the week went on, the room began to be filled with the artifacts of our arguments, questions, ideas, and underlying presuppositions. There were large handwritten posters (see Figures 12-22) plastering the walls with questions like, “what is the role of humanistic versus pedagogical values in the school culture” (see Figure 18)? And on other posters, there were words to argue over like “skills” (see Figure 15), “content” (see Figure 16), “design” (see Figure 12), and “presentation” (see Figure 13). There were printed posters (see Figures 23-29) that had statements where we would vote with a green sticker to see where we as a group had matching positions on PBL. Some of those posters read, “technology will be an integral and central part of the process, whether teacher or student-directed” (see Figure 26) and “teacher’s roles are to advise, facilitate, and participate in the project” (see Figure 24). No one in that room could have predicted that we would go on to open three more schools, under the same learning model, inside a large northeastern United States school district, in a climate where charter schools were the trend.

Being a founding staff member, combined with all the experiences of opening these schools and participating in their growth, positioned me to tell the stories and answer the question: how public school mathematics teachers create curriculum for urban schools using

project-based methodologies, in a specific learning model, that uses current technological resources? The following sections provide an analysis of the aforementioned question, beginning with a summary of my study and an explanation of the limitations. Lastly, I will conclude by discussing the implications for further research of PBL with iterative curriculum design.

### **Summary of Study**

Originally, I set out to interview four teachers. Unfortunately, Freeman School East became embroiled in a building structural safety issue which plagues many buildings built prior to 1980. This unforeseen event caused one of my participants to drop out of the study just after filling out the two questionnaires (see Appendix G and H). He was overwhelmed with the events and felt like being in the study would hinder the process I was asking him to engage with over a six-month time span. With the participants that remained, I was able to spend over twelve hours of time with them online and on phone calls.

Shortly after they filled out the two questionnaires, we began meeting online to conduct the semi-structured interviews. This began in September after I acquired the IRB and the participant's consent to be a part of my study. These participants were chosen for their content area and the number of years they have been teaching in the Freeman School's model. It was important to the results of this study that the participants had at least five years working inside of the Freeman School model. Any years fewer than five would prove an insufficient amount of experience to completely describe their experience about how they are creating curricula for urban schools using project-based methodologies, in a specific learning model, that uses current technological resources.

The semi-structured interviews could have gone on for longer than the prescribed hour because each participant was able to enthusiastically describe their experience and enjoyed



reflecting on their practice about how they created curricula. In addition to similarities of themes from the semi-structured interviews, each teacher had a personal journey to relate to me as they described their experiences. One memorable anecdote from each participant will demonstrate these differences.

Susan realized in the first year of working at Freeman that the curriculum she inherited was not what she considered to be PBL. Instead, it was a scaffolded experience leading to the same “right answer” for each student. I was surprised when Kim told me that even though she student-taught in the model at Freeman East, it still took her “two to three” years to work comfortably in the model at Freeman West, in her own classroom. And Adam relayed that it was his choice to start teaching as a second career, but it did not make the transition from running a company to running a classroom any easier. Each one of these journeys is different and it is important to note that these are the experiences that affect how the participants create their PBL math curricula.

In the months that followed the initial interviews, a cyclical practice of a narrative case study commenced (see Figure 2). Starting in September of 2019, I made appointments to meet up with each participant via email. These meetings were held individually and would last up to and, a few times, over an hour. During each interview, I recorded each participant with my cell phone using a voice recording application. After each interview, I uploaded the .mp4 file to temi.com to transcribe the audio file and deleted the audio file from my phone. I downloaded each transcription and saved them to two, password-protected, cloud-based digital storage folders. The raw audio files from my cell phone were also uploaded to both password-protected, cloud-based digital storage folders. This process was repeated, with each participant, until each interview was transcribed, digitally stored, and backed up in the cloud.

Once each transcript was complete, in February of 2020, I proceeded to upload each transcript to Dedoose to begin my coding. It was at this point that my novice researcher skills became obvious. I had chosen too many codes for the first read-through, so as I was searching for themes, I became bogged down in the minutia of the participant's stories and had to repeat the process with fewer codes at the beginning.

### **Conclusions and Initial Findings**

At this point in time, I began restorying Susan, Kim and Adams' experiences in creating curriculum. The restorying and coding revealed themes within their verbal accounts and I was able to find that each participant was dealing with, what I am calling, a curriculum conflict. The participants have significant experiences that involve iterative design thinking. Iterative design thinking is relevant to a constructivist's mindset and has been gaining traction in many modern problem-solving situations and iterative design thinking has recently been gaining popularity in education. And finally, the participants' interviews captured a structure to PBL that involves specific components that answer how they are creating math PBL.

In the above sections, I have introduced my discussion and summarized what happened during the course of the five-month study. In the next sections, I will answer the research questions and show where these answers have revealed new knowledge in the field of educational research.

## **Answering the Research Questions and New Knowledge**

### **Research Questions**

How are public school mathematics teachers—at the Freeman Schools—using project-based methodologies and leveraging existing technological resources in the development of urban school curricula?

- a. What influences public school math teachers in their efforts to write curriculum in schools that use laptops as a primary learning tool?

### **Answering the Research Questions**

Creating mathematics curriculum for urban schools using project-based methodologies, in a specific learning model that uses current technological resources involves three things for the participants in this study. As I stated above, they are: (a) participating in iterative curriculum design, (b) working out a curriculum conflict when creating UBD unit plans, and (c) they are adhering to a structure of PBL curriculum creation that is deeply influenced by the Freeman School Learning Model.

Kolb's (1984) theory on Adult Learning and the Experiential Learning Cycle is relevant to each theme in this study. Kolb (1984) says, "Learning is the process whereby knowledge is created through the transformation of experience" (p. 38). Kolb (1984) comes to this conclusion about experiential learning by synthesizing the work of Piaget and Dewey. Kolb (1984) touts that Piaget and Dewey's models of the learning process, when taken together, form a "unique perspective on learning" (p. 25) that are shared by three traditions of experiential learning and make up six propositions: (a) learning is best conceived as a process, not in terms of outcomes; (b) learning is a continuous process grounded in experience; (c) the process of learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world; (d) learning is a holistic process of adaptation to the world; (e) learning involves transactions between the person and the environment; and (f) learning is the process of creating knowledge.

Kolb's (1974) Adult Learning Theory has the most relevance because it demonstrates a cyclical nature to learning and building knowledge through experience. Kolb (1974) depicts the cycle as having four, consecutively repeating parts: (a) concrete experience, which is a new

experience or situation is encountered, or a reinterpretation of existing experience; (b) reflective observation of the new experience because any inconsistencies between experience and understanding are of particular importance; (c) abstract conceptualization reflection gives rise to a new idea, or a modification of an existing abstract concept; and (d) active experimentation is when the learner applies their idea(s) to the world around them to see what happens (Kolb, 1974).

In the next three sections I demonstrate how these teachers are steeped in adult learning theory as they experience the process of creating PBL curriculum. These answers to my research questions will lead into my conceptual framework, where I explain how it applies to my findings.

**Examples of Iterative Curriculum Design.** The first part of the three-pronged answer about how public-school mathematics teachers are creating curriculum is an ongoing process of iterations of UbD unit designs.

Each participant spoke about experiencing a process of iterations when creating their math PBL curriculum. They are each going through a process of design and redesign and this cycle presents itself in their answers during the semi-structured interviews.

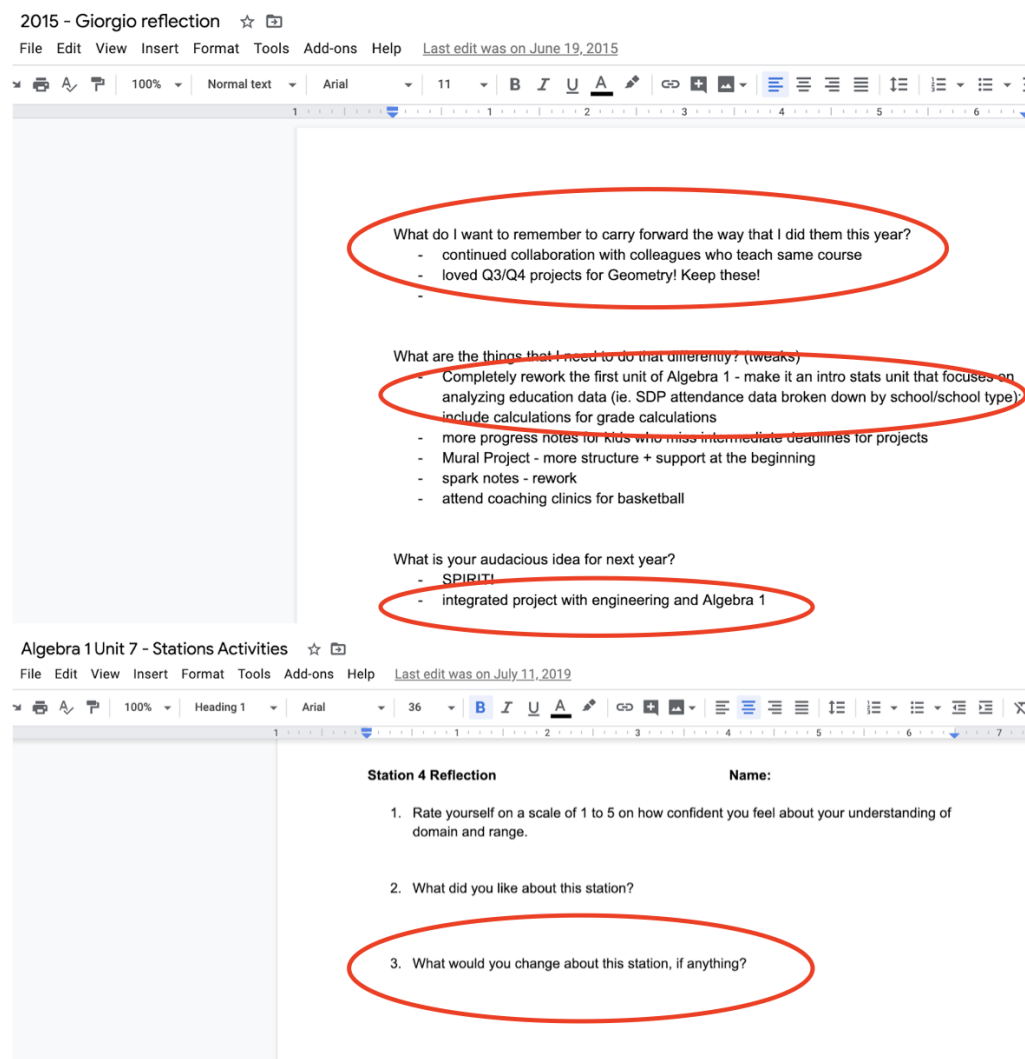
Below, I give examples that illustrate how the participants are experiencing these iterations. However, it is important to also ask why the participants are constantly in a cycle of “re-design”? When creating math PBL curriculum, the participants are not asking students to perform an act of memorization at the end of a unit that mirrors the content the teacher has provided for the student. Instead, the participants are creating learning experiences that require students to evidence their learning and in their process of learning the content as the student experiences the content, the participants had scaffolded together to include the most student choice and voice. And instead of a test to assess what knowledge the student has acquired, there

is a rubric to assess the student's presentation of the learning. The difference: the onus of producing knowledge is now the student's responsibility. The "hard work" the participants refer to in chapter four is the process it takes to create learning experiences that empower students to evidence their learning in a ten-week marking period cycle.

Therefore, the participants are constantly adding resources and ways to access the content of the created curriculum. They are also providing students with information about how to evidence their learning and how this learning will be assessed.

Kim collaborates with Susan on creating curriculum after she leaves her student teaching position at Freeman East and has her own classroom in Freeman West. Kim is working out math PBL units based off of the units Susan and she worked on. And Kim is applying the units to her curriculum (see Figure 6).

Susan is in constant collaboration with colleagues and students. Figure 28 shows two different digital documents. The top one is a reflection exercise that shows her planning, in detail, to make changes to her existing curriculum. And the second digital document shows her soliciting students for feedback on specific components in a lesson.

**Figure 28***Example of Susan Planning Iterations in Collaboration with Students and Colleagues*

(Susan Digital Archives - downloaded from [www.freemanschool/onlinearchives](http://www.freemanschool/onlinearchives))

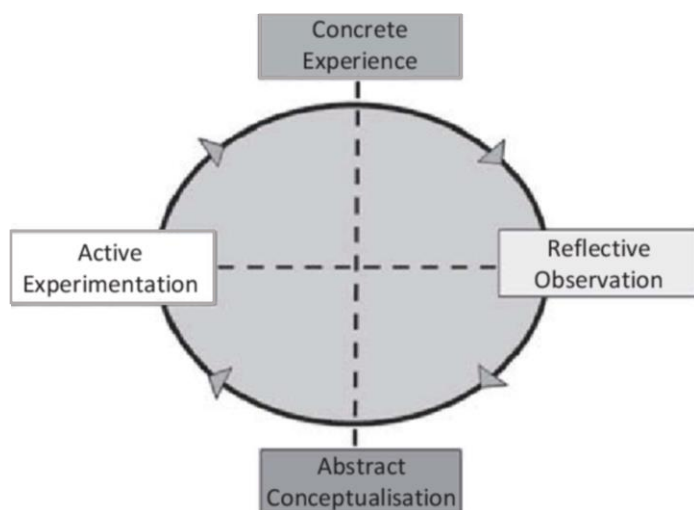
Adam's iterations are organized in an exacting "matrix" (see Figure 11) that he revisits at the end of each school year, or in times that are long enough for him to digest and reflect upon what had happened during the "active experimentation" (Kolb, 1984) phase of his curriculum creation.

Figure 29 shows Kolb's (1984) experiential learning cycle. This cycle supports what the

participants are experiencing as they go through the process of creating math PBL curriculum. Each participant has a concrete experience with writing and teaching their curriculum; then onto reflecting about the curriculum, revising the iteration (during an active unit in the classroom or later along or with colleagues), and teaching the revised (next iteration) curriculum. The cycle then repeats, indefinitely.

**Figure 29**

*Kolb's Experiential Learning Cycle*



(Kolb, 1984)

**Examples of Curriculum Conflicts.** The second and most stressful experience the participants are having is a curricular conflict when in the process of creation. Each participant experiences outside and inside pressures to prepare their students for standardized tests. The inner conflict and pressure stems from the tension that arises between creating lessons that will prepare students for standardized tests and their philosophy of teaching math concepts in a less traditional, non-linear fashion. The external pressure comes from three places: (a) the current academic system of standardized testing acting as a proverbial gatekeeper to a student's future

educational experience, (b) the expectations of the participants' learning community, and (c) the public recording of standardized test scores. Adding additional pressure to (b) the expectations of the participants' learning community is the "data-driven decision-making." These participants will have to discuss the results of these tests with fellow colleagues and their administrators in an effort for the school leaders to make curricular and budgeting decisions for the entire high school.

These pressures felt by the participants directly affect how teachers are creating curriculum. Each participant is thinking about the standardized tests and how to incorporate the skills the students will need to be successful into their math PBL curriculum.

Susan has a particularly strong reaction to this pressure. She states:

I'm not as stressed about touching upon all the required components in geometry as I am, as I am in algebra simply because it's a Graduation Standardized Test subject and it's probably one of the most fundamental courses that kids can take ... I need to make sure that they do well enough on the test. That one, is for our funding and that the district continues to leave us alone, so that we actually have the freedom that we currently have. But if we don't do well enough, then they're going to make us change. (Susan Interview 1)

Marcie: "Wow! What does that pressure do to you as a person?" (Susan Interview 1)

Susan: "Kills a little piece of me every day. You have no idea how stressful these keystones are for me." (Susan Interview 1)



When Susan says, “the district continues to leave us alone,” she is referring to Freeman School’s learning model. For the past fifteen years Freeman Schools have been exempt from the School District’s mandated “Core Curriculum.” The School District agreed when Freeman opened in 2006 that Freeman’s rubric (see Table 2) could quantify the projects so a percentage grade could be attached to student achievement and then officially recorded on the student’s transcript.

Adam and Kim deal with similar pressures. In recognition of what Adami’s future engineers will face, Adam assuages his curricular conflict by administering a midterm four times a year. This means Adam must take time away from his authentic PBL curriculum to teach discrete test-taking skills. This is in opposition to his earlier sentiments concerning his philosophy of teaching PBL math curriculum. Adam said:

I just don't want them to view math as being anything separate. I don't want them to view technology as being separate from nature. I don't want them to miss the joy of life in the continuum of all that. How it's all interconnected and that I want them to live it. (Adam Interview 2)

Kim’s reaction to her curriculum conflict is to be thoughtful about all the standardized test situations that she and her students are confronted with yearly. It is obvious that although Kim tries to keep standardized test preparation out of her experience of creating curriculum, she is thinking about this “challenge”. During our member-checking emails this was the one subject she wanted to clarify. Kim expounded:

... the balance between the Graduation Test prep in a project-based, inquiry-driven learning model is probably one of the hardest challenges of being an educator in this

school. While we do not put a huge emphasis on testing - we are more concerned with students' individual growth as learners and know that the scores do not account for many of the demographics and experiences of our individuals ... (Kim Interview 4)

Each participant is dealing with and reacting to the pressures of the curriculum conflict felt by PBL math curriculum creators. And each participant is reconciling the effects of this curriculum conflict experience in two ways: leaning into it and accepting the changes it makes to their curriculum or acknowledging it and resisting it by changing the curriculum. This is the second way public school mathematics teachers create curriculum for urban schools using project-based methodologies, in a specific learning model that uses current technological resources.

***Examples of the PBL Structure.*** The structure of the Freeman School learning model is the third and most replicable experience that the participants explain during the semi-structured interviews. This specific experience also explains, in a concrete way, how teachers are creating curriculum for urban schools using project-based methodologies, in a specific learning model that uses current technological resources.

Each participant's curriculum is permeated by the Freeman School's learning model and the most obvious place this structure can be seen is in the formal presentation of their units. The participants are using a UbD template (see Table 6) that has been augmented in order to accommodate Freeman School's common language (see Tables 1 and 3). This structure also includes a common rubric (see Table 2) for assessment of all the projects.

The core values are used in their curriculum to move students through projects in a familiar way. All projects start with inquiry and the essential questions for that unit. Most

projects incorporate the grade-wide theme into these preliminary questions. However, sometimes the theme can conclude a unit in the reflections stage. After inquiry comes research, which usually takes on a component of collaboration. And in the true sense of constructivism, the next step is presentation. Students show and explain what they have made, what they have brought into this world (Dewey, 1938; Jonassen et al., 2003; Kolb, 1984; Laufenberg & Lehmann, 2012; Martinez & Stager, 2012; Papert & Harel, 199), through presentation. And the two final steps to each project is assessment via the common rubric (see Table 2) and a reflection on the learning that occurred during the project. Each participant has a UbD in the Appendix showing the stages of their curriculum formally (see Appendix J and L, and Figures 5 and 6). The structure inherent to the Freeman School PBL learning model is the third and final way I have found to describe how public school mathematics teachers create curriculum for urban schools using project-based methodologies, in a specific learning model that uses current technological resources. In the next section, I resolve the sub-question posed in the beginning of these narrative case studies.

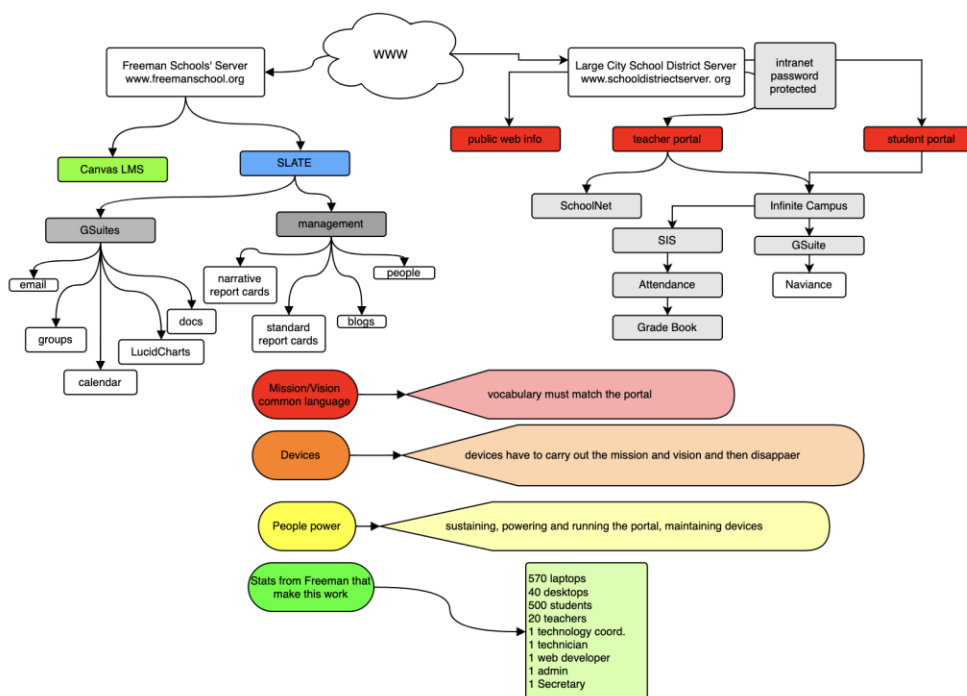
***Sub-Question.*** What influences public school math teachers in their efforts to write curriculum in schools that use laptops as a primary learning tool? When reading over this study, it could be determined that the use of technology, by the participants, is not addressed. However, the one-to-one laptop program and the use of tools from the internet are ever-present. Meaning, there is not an instance in the participant's creation process that the laptops are not a consideration. Therefore, I made the decision to explain the role of technology in the experience of the participants creating curriculum for urban schools using project-based methodologies, in a specific learning model that uses current technological resources, for this discussion in chapter five.

The semi-structured interviews asked how teachers are personally using technology

during their experience of creating math PBL curriculum. I also asked the participants how they are expecting students to use technology in the curriculum they are creating. In an effort to answer this question, I will focus on the overarching influences the participants are experiencing. I also layout, in Table 7, the expected laptop use in the curriculum the participants have created, citing the participants work in Appendix J, L and M.

Basically, the participants are influenced by the technology infrastructure made available to them and to their students while in and out of the physical school building. Freeman Schools' technology infrastructure consists of physical technologies, including inter/intra-nets (physical wires, routers, and the world-wide web (the uniform resource locators and packets that are connected by the inter/intra-nets). The physical technologies are laptops, varying kinds of printers, projectors, smart boards, cellular phones, and assistive technologies. The Freeman Schools' one-to-one laptop program ensures that every student and every teacher possesses a laptop (twenty-four hours a day and seven days a week). Said laptop is intended for academic use.

Freeman Schools have an intricate internet interface. I teach students and staff how to understand and use this infrastructure and, in order to do that, I created this graphic. I will use it here to illustrate this complex infrastructure. Simply put, Freeman Schools uses two servers that are used for "cloud-based computing." This figure illustrates what tools are used and where they can be found on the internet.

**Figure 30***Freeman Schools' Technology Infrastructure*

*Note.* This figure details the technological infrastructure employed by the Freeman Schools. There are two servers accessible by two separate single-sign-on user authentications. These authentications give users access to all the technological tools within each portal. The participants are using this infrastructure in tandem with their students while creating their math PBL curriculum.

Table 7 below details what technology tools the teachers are utilizing during instruction of their curriculum and how they are using them. It is important to acknowledge what each of these things are because all of these technological resources have a direct effect on how teachers are creating their curriculum. They are actively making choices about what to include in their curriculum based on the available technologies.

**Table 7***Specific Technology Use in the Participant's Curriculum*

<b>Appendix</b>	<b>Participant</b>	<b>Technology Infrastructure</b>	<b>Physical Technology</b>
<b>J</b>	<b>Susan</b>	<ul style="list-style-type: none"> <li>➤ Students access content and resources via Freeman School LMS - i.e. directions, rubrics, and grades</li> <li>➤ graphing software</li> <li>➤ online research queries via browsers</li> <li>➤ video editing software</li> <li>➤ digital word processing software - for notes, collaboration with other students, summative reflections</li> </ul>	<ul style="list-style-type: none"> <li>➤ Laptops</li> <li>➤ Projectors</li> <li>➤ Interactive White Boards</li> <li>➤ Printers</li> </ul>
<b>M</b>	<b>Kim</b>	<ul style="list-style-type: none"> <li>➤ Students access content and resources via Freeman School LMS - ie. directions, rubrics, and grades</li> <li>➤ Personalized math learning software login for lessons and formative and summative diagnostics</li> <li>➤ online research queries via browsers</li> <li>➤ digital word processing software - for notes, collaboration with other students, summative reflections</li> <li>➤ graphing software</li> </ul>	<ul style="list-style-type: none"> <li>➤ Laptops</li> <li>➤ Projectors</li> <li>➤ Interactive White Boards</li> <li>➤ Printers</li> </ul>
<b>L</b>	<b>Adam</b>	<ul style="list-style-type: none"> <li>➤ Students access content and resources via Freeman School LMS - ie. directions, rubrics, and grades</li> <li>➤ industry appropriate software use for engineering drawing and creation of 3-D printing files, prototyping</li> <li>➤ digital word processing software - for notes, collaboration with other students, summative reflections</li> <li>➤ online research queries via browsers</li> </ul>	<ul style="list-style-type: none"> <li>➤ Laptops</li> <li>➤ Projectors</li> <li>➤ Interactive White Boards</li> <li>➤ Printers</li> <li>➤ 3-D printers</li> </ul>

*Note.* Listed in this table are the technologies included in the participant's math PBL curriculum

chosen from all the available technology at Freeman School.

Adam's approach is to treat the technology like any other tool. He uses it personally for designing and solving problems. Adam models his use by building experiences with his approach into his curriculum. Susan wrote into her unit plan, "use appropriate tools strategically (Susan, Appendix I). This gives students choices within the technological infrastructure. Lastly, Kim stays as "low tech" as possible, she says:

I don't find it relevant to math teaching. And I think there isn't that much targeted towards math teachers. . . . And I think there is in some ways a need for students to be doing paper and pencil type of things in math because I think that that it actually helps with their reasoning. So I think there's a reason for technology, but I think that there are probably more opportunities out there to use certain technology that I am not as, um, proficient in as I could be. (Susan Interview 2)

Susan acknowledges that there is a lot available in terms of using technology in her curriculum. However, she believes there is more to be gained in these experiences through the use of paper and pencils.

In this section, I have described the complex technology available to the participants while creating their curriculum. I have also brought attention to the high quality of the technology available at the Freeman Schools. This disappearance of specific references to technology is part of the Freeman Learning Model; the technology is so pervasive that it disappears. Through the philosophy of ubiquitous technology, learning becomes the focus instead of learning about the technology. Simply put, the technology is the structure embedded in the participant's curriculum that supports the learning not the structure that drives the learning.

## **Application of Conceptual Framework to Findings**

The foundation of my conceptual framework that I discussed in chapter two is the idea that PBL curriculum creation relies on a teacher's ability to interpret, produce, and model their own experiences (Carver, 1996), and Dewey's (1938) theory that teachers are the connectors of growth—their own and that of their students. This growth is framed by a teacher's use of knowledge to select and arrange the conditions that influence a student's present experience (Dewey, 1938, p. 78) based on their own experiences.

Applying my conceptual framework to the data I collected, I found that teachers experiencing the creation of math PBL curricula go through iterative design thinking and iterative curriculum design. Teachers creating math PBL curricula also experience a curricular conflict within their philosophical belief toward PBL when they are confronted with student skill-building toward a mathematical standardized test versus student skill-building toward critical thinking through a mathematical lens.

There are four other sub-themes that are a part of the discussion in chapter five and relate to the conceptual framework that appeared in the analysis of the data. These four themes are how the experience of teacher learning and student learning are enhanced with (a) ubiquitous technology, (b) collaboration, (c) the Freeman School Model's common language, and (d) the notion of an ethic of care

Dewey (1938) theorizes progressive experiential learning aids in the construction of knowledge. Savery and Duffy (1995) consider PBL to be the best example of a constructivist learning environment. Savery and Duffy (1995) write, "[c]onstructivism is a philosophical view on how we come to understand or know" (Savery & Duffy, 1995, p. 2). The participants in this study come to understanding and True knowing through experiencing iterations of creating their



curricula. The level of commitment to building and creating curricula takes persistence and tenacity to consistently collaborate, revise and revisit. However, it is this commitment that leads to the experience of True knowing in the field of PBL.

### **Limitations of the Study**

This narrative case study had limitations due to the uniqueness of Freeman Schools, my novice researching skills with coding, and my positionality as founding staff at Freeman Schools. Below I describe these limitations.

### **Limitations in Generalizability**

Freeman Schools are a unique group of schools in a large northeastern urban area. The most significant limitation within this study is the extremity of the uniqueness of these schools. There are few urban public schools that opened with the intention of creating curriculum strictly inside of a PBL model. However, there are parts of this story that are transferable to schools involved in or beginning a PBL initiative. There is knowledge to be gleaned from skill building curriculum conflicts, mathematics PBL structures, and iterative design experiences occurring during curriculum creation that can be generalized.

### **Limitations in Methodology**

The truncated schedule for obtaining the IRB and completing the written dissertation is a limitation to this study. Having time to reflect, and practicing reflexivity more than once would have been a more propitious timeline for this type of methodology.

### **Limitations in Limitations in Analysis**

There are two limitations to my analysis. The one that hindered the research the most was the deductive coding folksonomy I used in Dedoose. The codes are backwards (see Figure 1). It would have been faster to start with three to four codes at the beginning of the analysis and end

with as many codes necessary to describe the data correctly.

The second limitation to the analysis is my positionality. I have lived alongside the experiences of my participants and this can make it difficult to identify blind spots in the analysis of the data. It can also hinder my ability to fully explain details of the Freeman learning model or the participants' experience because of my deep understanding of both of those components to the “rich, thick descriptions” (Merriam & Tisdell, 2015, p. 257).

### **Implications of Future Educational Research**

The telling and retelling of the participant's stories (Clandinin & Connelly, 2000) in this segment of time that resulted in knowledge and understanding, about an iterative design process that teachers are experiencing while creating curriculum for urban schools using project-based methodologies, in a specific learning model. (incomplete sentence...don't understand it) This knowledge gives merit to future research concerning the creation of original math PBL curriculum and the iterative design approach. There needs to be more knowledge concerning the structures involved in PBL as teachers are cycling through the creation process in order for math PBL curriculum creation to be replicable to a wider range of educators (Corcoran & Silander, 2009, Angelle, 2018).

### **Summary**

In the above section, I analyzed data from field notes, digital artifacts, and teacher interviews. I then documented, in detail, how math teachers are creating curriculum in an inquiry-driven, project-based, technology-infused instructional model. This analysis of three-dimensional space, regarding teacher lore, revealed themes inherent to the experiences of math teachers in creating curriculum. My findings show skill-building curriculum conflicts, mathematics PBL structures, and iterative design experiences occurring during curriculum

creation by the participants; all of which add new knowledge and understandings to the field of education.

These narrative case studies synthesize a segment in time by restorying (Clandinin & Connelly, 2000) the experiences of the three participants creating math PBL curriculum. And in closing, these findings call for future research to be conducted concerning iterative curriculum design in regard to original math PBL curriculum creation.

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## Tables

**Table 1**

*The Freeman Schools' Demographics*

<b>School Year 2019-2020</b>	<b>East Campus</b>	<b>West Campus</b>
Grade level	9th - 12th	9th - 12th
Student enrollment	499	479
English as a second language count	11	24
English as a second language PCT	2.2	20.28
Not English as a second language Count	488	455
Not English as a second language PCT	97.8	379.72
Individualized education plan count	52	51
Female count	260	248
Male count	239	231
American Indian count	0	1
American Indian PCT	0	0.77
Asian count	50	19
Asian PCT	10.02	16.12
Black African American count	181	335
Black African American PCT	36.27	279.71
Hispanic count	67	44
Hispanic PCT	13.43	36.4
Multi-race count	28	22
Multi-race PCT	5.61	18.65
Pacific Islander count	0	0
Pacific Islander PCT	0	0

White count	173	58
CEP Economically disadvantaged rate	46.81	64.58

**Table 2***The Freeman School Rubric*

	Design	Knowledge	Application	Presentation	Process
Exceeds expectations					
Meets expectations					
Approaches expectations					
Does not meet expectations					

**Table 3***Freeman School's Grade Level Essential Questions*

Grade - Theme	Essential Questions
9 - Identity	<ol style="list-style-type: none"> <li>1. Who am I?</li> <li>2. How do I interact with the environment?</li> <li>3. How does the environment affect me?</li> </ol>
10 - Systems	<ol style="list-style-type: none"> <li>1. How are systems created?</li> <li>2. How do systems shape the world?</li> <li>3. What is the role of the individual in systems?</li> </ol>
11 - Change	<ol style="list-style-type: none"> <li>1. What causes systemic and individual change?</li> <li>2. What is the role of the individual in creating and sustaining change?</li> <li>3. What is the relationship between the self and a changing world?</li> </ol>
12 - Creation	Seniors create essential questions for their Capstone, the inquiry project required for graduation from Freeman Schools



**Table 4***Freeman School's Core Values*

<b>Core Value</b>	<b>Academic Intent</b>
<b>Inquiry</b>	Inquiry-driven learning is essentially scientific thinking. Students start by posing a hypothesis, question, problem or scenario to explore. They identify relevant topics to pursue, conduct research, and piece together the solution. Students establish or confirm facts, solve new or existing problems, and develop theories.
<b>Research</b>	Research is the examination of information to confirm facts and theories and add to existing knowledge. Students explore topics and ideas, sometimes analyzing conflicting data to synthesize and apply their findings as to knowledge in the context of what they knew before.
<b>Collaboration</b>	Collaboration is teamwork. Students form partnerships to take advantage of one another's skills and resources to build knowledge on a topic. They explore data jointly, share information, discuss their findings, determine relevance, evaluate one another's ideas, monitor each other's efforts, and present what they've learned together.
<b>Presentation</b>	Presentation is the demonstration or performance of what students know and are able to do. As they acquire the knowledge about a specific topic or inquiry, they incorporate thinking about how to apply or present the information so that others will understand it, learn from it, and derive value from it.
<b>Reflection</b>	Reflection is the act of considering an idea carefully and determining its value in a given situation. Students review the ideas and data they encounter and contemplate their value to the problem or inquiry they are exploring. They may find conflicting information, ideas that contradict what they hypothesized initially, or data that isn't appropriate to the situation. They have to analyze the information and apply what they think is relevant. In the process, they have to examine how they are evaluating the information to make sure they view it accurately.

**Table 5***Participant Demographic Comparison*

	Degree	Years of Teaching	Hrs./week Teaching	Currently Teaching	Hrs/week Planning
<b>Susan</b>	Undergraduate in Psychology, Masters in Physical Education, Masters in Secondary Education	11-15	35	9-11 Algebra, Geometry	15
<b>Kim</b>	B.A. in Mathematics, Masters in Education	0-5	21	9-12 Algebra, Geometry, Calculus	18
<b>Adam</b>	BSME, MSME (Mechanical Engineering)	6-10	20	9-12 Engineering	20

**Table 6**

Freeman School's Augmented UBD Template

<b>STAGE 1: Desired Results</b>		
Grade-Wide E-Qs	Transfer	
	<i>Students will be able to independently use their learning to...</i>	
	Meaning	
	<b>Understandings</b> <i>(What specifically should students be able to understand after completing the unit?)</i>	<b>Essential Questions</b> <i>(What thought-provoking questions will foster meaning-making, inquiry and transfer?)</i>
Established Goals	Acquisition of Knowledge and Skill	
	<b>Students will know...</b> <i>(What facts and basic concepts should students know and be able to recall?)</i>	<b>Students will be skilled at...</b> <i>(What skills and processes should students be able to draw upon and use?)</i>



<b>Research</b> <i>(When and how will students search for information during this unit?)</i>	
<b>Collaboration</b> <i>(When will students be working together during this unit?)</i>	
<b>Presentation</b> <i>(How will students be displaying their work and to whom?)</i>	
<b>Reflection</b> <i>(When will students be able to look back upon their work and their learning?)</i>	

Freeman Standards-Based Reporting	
Subject-Specific Standard	Assessment or Task Evaluating Standard
<i>(Which departmental standards will this unit address?)</i>	<i>(Which assignments will be used for assessing students' progress?)</i>

Reading Strategies	
Strategies	Activities
<i>(What strategies will be used to improve reading comprehension and access to information?)</i>	<i>(Which assignments will incorporate these reading across the curriculum strategies?)</i>

STAGE 3: Learning Plan	
Daily Learning Activities and Notes	
Day1	
	<p><i>The single most important thing we have to do this class is...</i></p> <p><i>If we accomplish nothing else this class we have to...</i></p>
Day 2	
	<p><i>The single most important thing we have to do this class is...</i></p> <p><i>If we accomplish nothing else this class we have to...</i></p>
Day 3	
	<p><i>The single most important thing we have to do this class is...</i></p>

Resources and Links	
Source	Link or Citation

Appendix A: Projects and Assignment Sheets
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Appendix B: Rubrics and Grading Criteria
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Appendix C: State/National Standards
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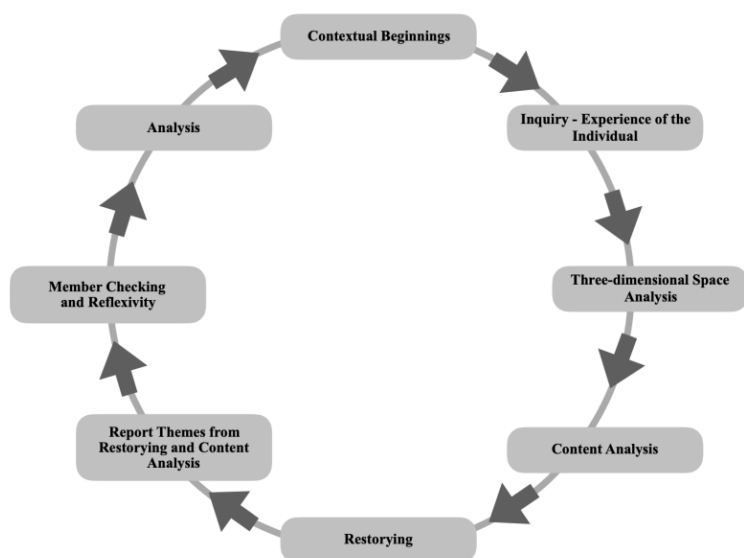
**Table 7***Specific Technology Use in the Participant's Curriculum*

Appendix	Participant	Technology
J	Susan	<ul style="list-style-type: none"> <li>➤ Students access content and resources via Freeman School LMS - ie. directions, rubrics, and grades</li> <li>➤ graphing software</li> <li>➤ online research queries via browsers</li> <li>➤ video editing software</li> <li>➤ digital word processing software - for notes, collaboration with other students, summative reflections</li> </ul>
M	Kim	<ul style="list-style-type: none"> <li>➤ Students access content and resources via Freeman School LMS - ie. directions, rubrics, and grades</li> <li>➤ Personalized math learning software login for lessons and formative and summative diagnostics</li> <li>➤ online research queries via browsers</li> <li>➤ digital word processing software - for notes, collaboration with other students, summative reflections</li> <li>➤ graphing software</li> </ul>
L	Adam	<ul style="list-style-type: none"> <li>➤ Students access content and resources via Freeman School LMS - ie. directions, rubrics, and grades</li> <li>➤ industry appropriate software use for engineering drawing and creation of 3-D printing files, prototyping</li> <li>➤ digital word processing software - for notes, collaboration with other students, summative reflections</li> <li>➤ online research queries via browsers</li> </ul>

## Figures

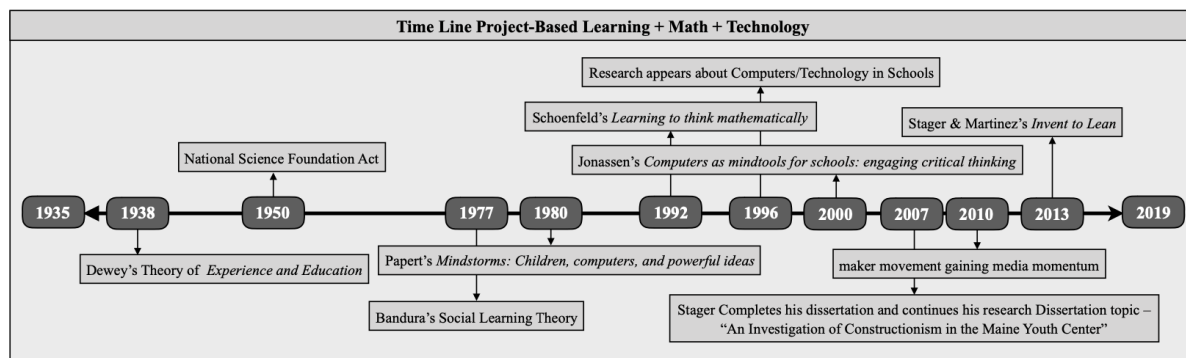
**Figure 1**

*The Cycle of Narrative Inquiry within Three-Dimensional Space Analysis*



**Figure 2**

*Timeline of Literature Pertaining to Technology and Math PBL*



**Figure 3**

*The hierarchical code folksonomy for thematic analysis*

Depth	Code Title Level 0	Depth	Code Title Level 1	Depth	Code Title Level 2
0	achievement				
0	assessments				
0	attitude				
↳	→ → → → →	1	belief		
0	behavior				
0	belief				
0	clear expectations				
0	common language				
↳	→ → → → →	1	collaboration		
↳	→ → → → →	1	inquiry		
↳	→ → → → →	1	reflection		
↳	→ → → → →	1	research		
0	continuity				
↳	→ → → → →	1	future		
↳	→ → → → →	1	past		
↳	→ → → → →	1	present		
0	culture				
0	curricular conflict				
0	curriculum				
0	grading				
0	how				
↳	→ → → → →	1	expectations		
↳	→ → → → →	1	reflection		
		↳	→ → → → →	2	student reflection
		↳	→ → → → →	2	teacher reflection
↳	→ → → → →	1	skills		
↳	→ → → → →	1	skills assessment		
↳	→ → → → →	1	timing		
↳	→ → → → →	1	structure		
↳	→ → → → →	1	student choice		
↳	→ → → → →	1	student voice		
↳	→ → → → →	1	teacher research		
↳	→ → → → →	↳	→ → → → →	2	collaboration
↳	→ → → → →	1	teacher roles		
		↳	→ → → → →	2	coach
		↳	→ → → → →	2	designer
		↳	→ → → → →	2	facilitator
		↳	→ → → → →	2	learner
0	Interaction				
↳	→ → → → →	1	colleagues		
↳	→ → → → →	1	Personal		
↳	→ → → → →	1	social		
0	intervention				
0	iteration				
0	learning management system				
0	modality				
0	offline				
0	online tools				
0	p4ce				
↳	→ → → → →	1	past		
↳	→ → → → →	1	philosophy		
0	presentation				
0	prof. growth				
0	professional development				
0	reflection				
0	resources				
0	roles of teacher				
0	rubric				
0	situation/place				
↳	→ → → → →	1	online		
0	standards				
0	success				
0	PBL				
↳	→ → → → →	1	ex. lesson PBL		
0	Technology				
↳	→ → → → →	1	cell phone		
↳	→ → → → →	1	computer		
↳	→ → → → →	1	software		
0	understanding by design				
0	LMS				
0	Structure of PBL				

**Figure 4**

*Presentation slide examples from Social Justice by the Numbers presentation*

### Algebra 2 Project

- Focused on Probability, Statistics and Data Analysis through a Social Justice lens.
- Students choose a social justice theme that interested them (we suggest possible topics, or they can propose a topic of their own).
- Students then collaborate on a research-based statistical analysis of their topic.

### Algebra 2 Project

#### Final Products:

- A formal written report including:
  - A mathematical analysis of the topic from each group member.
  - Visual representations of key data.
  - A “Recommendations for Future Action” section.
- A 2-5 minute video PSA

**Figure 5***Example of Kim's Curriculum*

<b>Goals:</b> <ul style="list-style-type: none"> <li>How and why do we <u>write, simplify, evaluate, and solve</u> algebraic equations/expressions?</li> </ul>	
<b>Unit Essential Questions:</b> <ul style="list-style-type: none"> <li>What are algebraic expressions &amp; why use them?</li> <li>What are equations? What does it mean to "solve for a variable?"</li> <li>What does "simplifying" mean in math? Why do it?</li> <li>Is the correct mathematical answer to an equation always the best solution?</li> <li>When does solving for a variable find use in the real world?</li> </ul>	<b>Understandings:</b> <i>Students will understand that...</i> <ul style="list-style-type: none"> <li>Algebraic statements provide a systematic and precise way to capture and understand some life situations.</li> <li>The value of a variable can only be determined if the variable is isolated.</li> <li>Simplifying helps us make sense of solution and have more concise justifications.</li> <li>Correct mathematical solutions may not mean the best solutions.</li> <li>There are a variety of contexts where solving for a variable is useful</li> </ul>
<b>Students will know . . .</b> <ul style="list-style-type: none"> <li>Rules for <b>simplifying expressions</b> by adding, subtracting, multiplying, and dividing.</li> <li>Equation as a consisting of a pair of <b>equivalent expressions</b>.</li> <li>Key vocabulary related to the concepts <b>opposite, reciprocal, inverse operation</b>.</li> <li>The meaning of <b>isolating a variable</b>.</li> </ul>	<b>Students will be able to...</b> <ul style="list-style-type: none"> <li>Use the Distributive Property and explain what it means in applied contexts.</li> <li>Apply Properties of Operations and explain what they mean.</li> <li>Identify and write equivalent expressions.</li> <li>Use opposite, reciprocal, and inverse operations to solve for a variable.</li> <li>Simplify expressions correctly:             <ul style="list-style-type: none"> <li>Multiply</li> <li>Add/Subtract</li> <li>Dividing by a monomial</li> </ul> </li> <li>Evaluate expressions.</li> </ul>

Figure 6

Example of Kim’s Curriculum Planning

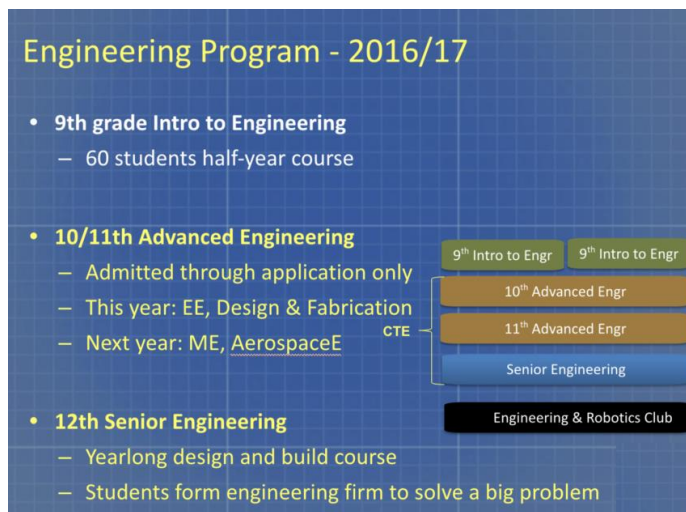
Teachers: Kim

Adapted from Freeman East - Kim

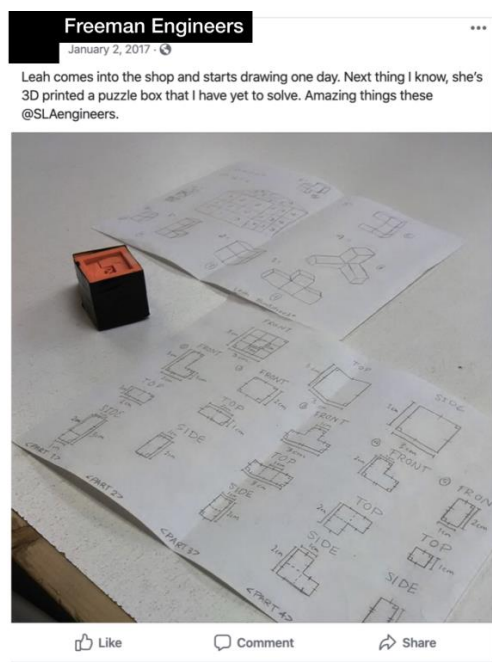
Algebra 1 UbD Unit 3 - Intro to Expressions and Equations	
<b>Goal:</b> <ul style="list-style-type: none"><li>Students will be able to write, simplify, evaluate, and solve algebraic equations/expressions</li><li>Students will understand when and why we use equations to solve problems.</li></ul>	<b>Unit Essential Questions:</b> <ul style="list-style-type: none"><li>What are algebraic expressions &amp; why use them?</li><li>What are equations? What does it mean to "solve for a variable?"</li><li>What does "simplifying" mean in math? Why do it?</li><li>Is the correct mathematical answer to an equation always the best solution?</li><li>When does solving for a variable find use in the real world?</li></ul>
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<b>Students will be able to...</b> <ul style="list-style-type: none"><li>Use the Distributive Property and explain what it means in applied contexts.</li><li>Apply Properties of Operations and explain what they mean.</li><li>Identify and write equivalent expressions.</li><li>Use opposite, reciprocal, and inverse operations to solve for a variable.</li><li>Simplify expressions correctly.</li><li>Evaluate expressions.</li><li>Solve one-step, two-step, and multi-step equations in one variable.</li></ul>	<b>Performance Tasks:</b> <ul style="list-style-type: none"><li>Standards-based assessments</li><li>Problem sets</li><li>Multiple Small Group Classwork Assignments</li><li>Daily Warm-up Problems</li><li>Benchmark Project: Budget proposal and solving for a variable</li></ul>

**Figure 7**

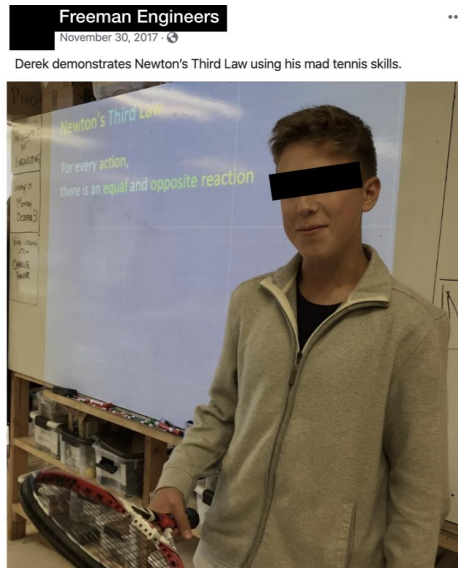
*Adam's Student Curriculum Map at Freeman School East*

**Figure 8**

*Example of math in service of creation*






**Figure 9***Newton's Third Law through tennis*

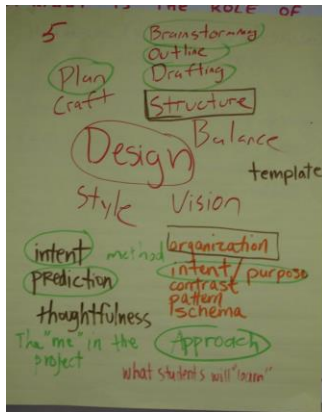
**Figure 10**

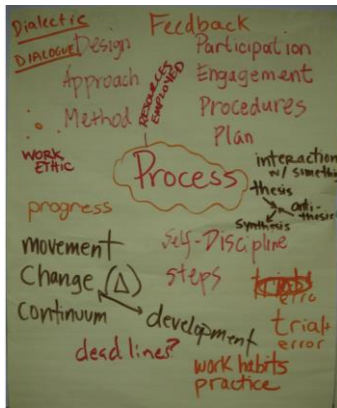
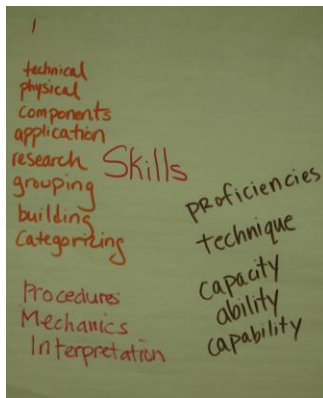
*Juxtaposition of curricular examples to formal UBD documentation*

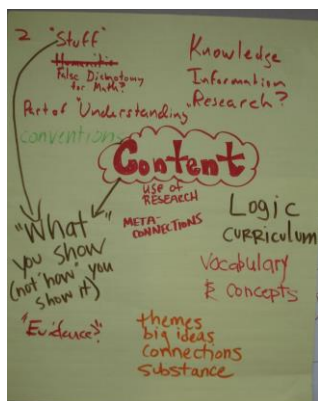
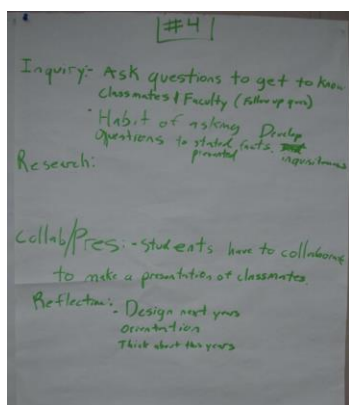
<div data-bbox="321 422 917 894"> <h3>Introduction to Engineering - 9th grade</h3> <p><b>Enduring Understandings</b></p> <ul style="list-style-type: none"> <li>The made world is <b>highly designed</b></li> <li>The <b>form</b> of a designed object <b>follows its function</b></li> <li><b>Brainstorming well</b> is based on a set of <b>best practices</b></li> <li>The <b>engineering design process</b> is <b>universal</b> to problem solving</li> <li>You will <b>always fail</b> during engineering in the beginning</li> <li>Good engineers <b>fail quickly</b> and <b>learn from their failures</b></li> <li>Engineering is an <b>iterative</b> process - <b>fast iterations</b> are the key</li> <li>Engineers <b>build on the work of others</b> - <b>research</b> is essential</li> <li>A design or solution is <b>meaningless unless communicated well</b></li> </ul>  </div>											
<table border="1"> <thead> <tr> <th>Students will understand that:</th><th>Essential Questions:</th></tr> </thead> <tbody> <tr> <td> <ul style="list-style-type: none"> <li>Safety is paramount in the shop and safety procedures must be followed at all times</li> <li>The made world is highly designed</li> <li>The form of a designed object follows its function</li> <li>Brainstorming well is based on a set of best practices</li> </ul> </td><td> <ol style="list-style-type: none"> <li>In what ways are engineering and science similar and different?</li> <li>How can we know how well the form of an object follows its function?</li> <li>Why is the engineering design process cyclical?</li> <li>In what ways do engineers utilize the knowledge embedded in the designs of nature?</li> <li>How do engineers communicate their designs?</li> </ol> </td></tr> <tr> <td> <ul style="list-style-type: none"> <li>The engineering design process is universal to problem solving</li> <li>You should expect to fail during engineering in the beginning</li> <li>Good engineers fail quickly and learn from their failures</li> <li>Engineering is an iterative process - fast iterations are the key</li> <li>Engineers build on the work of others - research is essential</li> <li>A design or solution is meaningless unless communicated well</li> </ul> </td><td> <ol style="list-style-type: none"> <li>What makes a team function well?</li> <li>How do makers actively assure safety when using shop tools?</li> </ol> </td></tr> <tr> <th>Transfer:</th><th>SLA-Wide Essential Questions:</th></tr> <tr> <td> <ul style="list-style-type: none"> <li>Effective collaboration is an essential element in most fields of work</li> <li>The engineering design process is applicable to many problem-solving situations</li> <li>Successful execution of a design requires care and quality, regardless of the field</li> <li>Failing is a constructive part of design</li> </ul> </td><td> <p><u>Identity</u></p> <p>How does the design of a natural or made object affect me?</p> <p>What about me informs my design work?</p> <p>What is my role in the work group, and how does my makeup impact the way I collaborate?</p> </td></tr> </tbody> </table>		Students will understand that:	Essential Questions:	<ul style="list-style-type: none"> <li>Safety is paramount in the shop and safety procedures must be followed at all times</li> <li>The made world is highly designed</li> <li>The form of a designed object follows its function</li> <li>Brainstorming well is based on a set of best practices</li> </ul>	<ol style="list-style-type: none"> <li>In what ways are engineering and science similar and different?</li> <li>How can we know how well the form of an object follows its function?</li> <li>Why is the engineering design process cyclical?</li> <li>In what ways do engineers utilize the knowledge embedded in the designs of nature?</li> <li>How do engineers communicate their designs?</li> </ol>	<ul style="list-style-type: none"> <li>The engineering design process is universal to problem solving</li> <li>You should expect to fail during engineering in the beginning</li> <li>Good engineers fail quickly and learn from their failures</li> <li>Engineering is an iterative process - fast iterations are the key</li> <li>Engineers build on the work of others - research is essential</li> <li>A design or solution is meaningless unless communicated well</li> </ul>	<ol style="list-style-type: none"> <li>What makes a team function well?</li> <li>How do makers actively assure safety when using shop tools?</li> </ol>	Transfer:	SLA-Wide Essential Questions:	<ul style="list-style-type: none"> <li>Effective collaboration is an essential element in most fields of work</li> <li>The engineering design process is applicable to many problem-solving situations</li> <li>Successful execution of a design requires care and quality, regardless of the field</li> <li>Failing is a constructive part of design</li> </ul>	<p><u>Identity</u></p> <p>How does the design of a natural or made object affect me?</p> <p>What about me informs my design work?</p> <p>What is my role in the work group, and how does my makeup impact the way I collaborate?</p>
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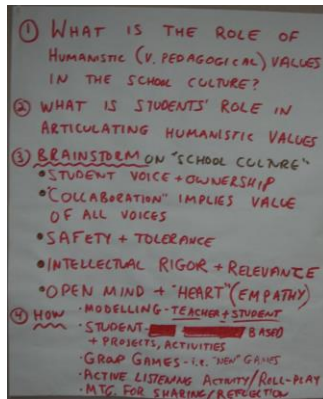
**Figure 11**  
*Examples of iterations in digital documents*

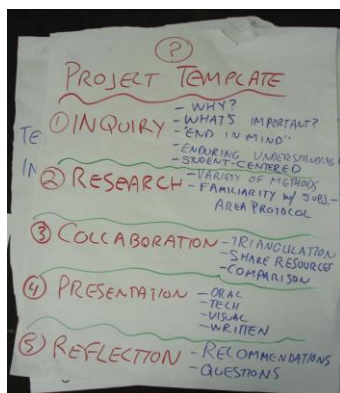
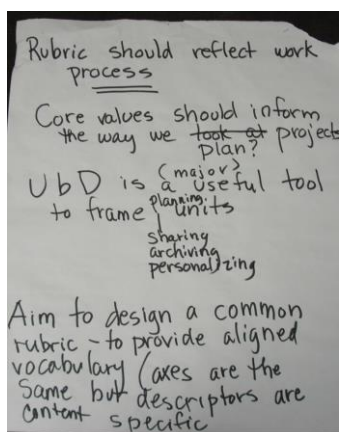
<div><div>Name ↓</div><div><div><div><div></div></div><div>OLD Curriculum prior to 2019-20</div></div><div><div><div></div></div><div>Carpenter's Hat</div></div><div><div><div></div></div><div>2019-20 Sr. Engineering Workspace</div></div><div><div><div></div></div><div>2018-19 Sr. Engineering Workspace</div></div><div><div><div></div></div><div>2017-18 Sr. Engineering Workspace</div></div><div><div><div></div></div><div>2016-17 Sr. Engineering Workspace</div></div><div><div><div></div></div><div>2015-16 Sr. Engineering Workspace</div></div><div><div><div></div></div><div>2014-15 Sr. Engineering Workspace</div></div><div><div><div></div></div><div>_Capstone Thursdays</div></div><div><div><div></div></div><div>GANTT CHART TEMPLATE</div></div></div></div>	<div><div>Name ↓</div><div><div><div><div></div></div><div>Unit 05 - Final Day</div></div><div><div><div></div></div><div>Unit 04 - Spreadsheets</div></div><div><div><div></div></div><div>Unit 03 - Design and Fabrication - The Balloon Car C</div></div><div><div><div></div></div><div>Unit 02 - Design and Fabrication - The Bridge Challe</div></div><div><div><div></div></div><div>Unit 01 - Engineering Design Process</div></div><div><div><div></div></div><div>Unit 00 - Welcome to Engineering</div></div><div><div><div></div></div><div>_UbD</div></div><div><div><div></div></div><div>_Old Not Used</div></div><div><div><div></div></div><div>_Assessment &amp; Grading</div></div></div></div>
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**Figure 12***Socratic Discussion Poster 1***Figure 13***Socratic Discussion Poster 2*

**Figure 14***Socratic Discussion Poster 3***Figure 15***Socratic Discussion Poster 4*

**Figure 16***Socratic Discussion Poster 5***Figure 17***Socratic Discussion Poster 6*

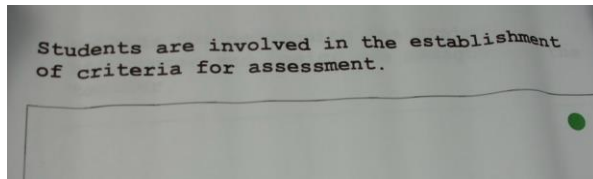
**Figure 18***Socratic Discussion Poster 7***Figure 19***Socratic Discussion Poster 8*

**Figure 20***Socratic Discussion Poster 9***Figure 21***Socratic Discussion Poster 10*

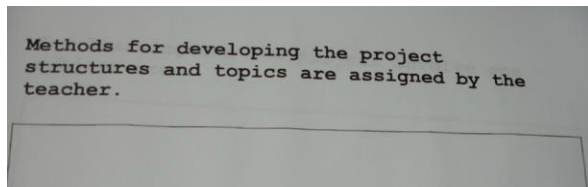


**Figure 22**

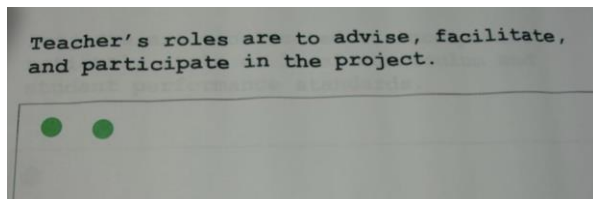
*Socratic Discussion Typed Voting Poster 1*

**Figure 23**

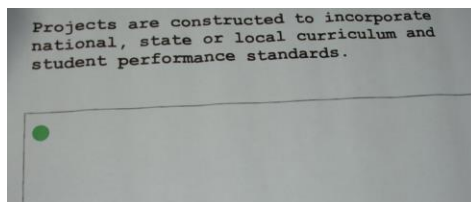
*Socratic Discussion Typed Voting Poster 2*

**Figure 24**

*Socratic Discussion Typed Voting Poster 3*

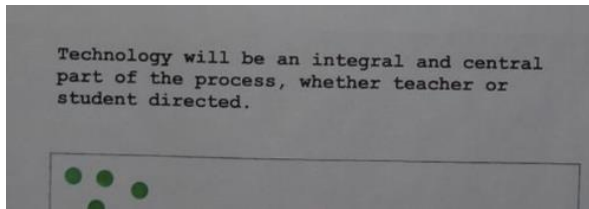
**Figure 25**

*Socratic Discussion Typed Voting Poster 4*

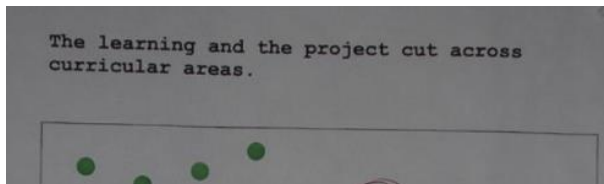


**Figure 26**

*Socratic Discussion Typed Voting Poster 5*

**Figure 27**

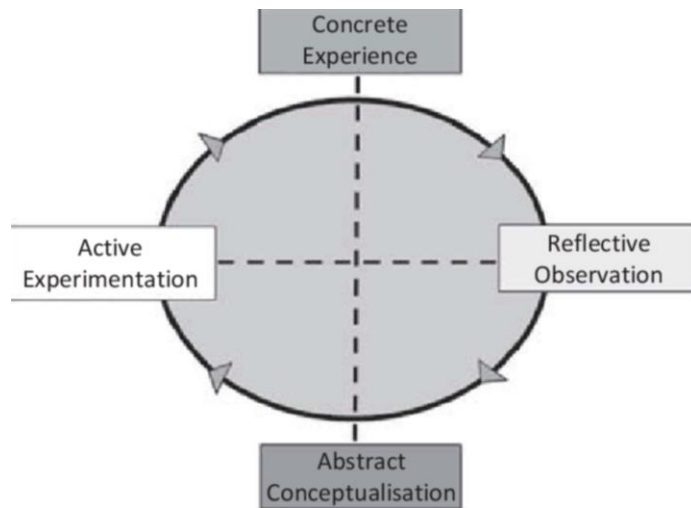
*Socratic Discussion Typed Voting Poster 6*





**Figure 29**

*Kolb's experiential learning cycle*



## Appendices

### Appendix A

#### Institutional Review Board Approval



Office of Research and Sponsored Programs | West Chester University | Wayne Hall  
West Chester, PA 19383 | 610-436-3557 | [www.wcupa.edu](http://www.wcupa.edu)

Protocol ID # 20190905A

TO: Marcie Hull & David Backer

FROM: Nicole M. Cattano, Ph.D.  
Co-Chair, WCU Institutional Review Board (IRB)

DATE: 9/4/2019

**Project Title: Math Teachers and Nonlinear Learning with Laptops: Narrative Case Studies**

**Date of Approval: 9/4/2019**

☒ **Expedited Approval**

This protocol has been approved under the new updated 45 CFR 46 common rule that went in to effect January 21, 2019. As a result, this project will not require continuing review. Any revisions to this protocol that are needed will require approval by the WCU IRB. Upon completion of the project, you are expected to submit appropriate closure documentation. Please see [www.wcupa.edu/research/irb.aspx](http://www.wcupa.edu/research/irb.aspx) for more information.

*Any adverse reaction by a research subject is to be reported immediately through the Office of Research and Sponsored Programs via email at [irb@wcupa.edu](mailto:irb@wcupa.edu).*

Signature:

Co-Chair of WCU IRB

WCU Institutional Review Board (IRB)




IORG#: IORG0004242

IRB#: IRB00005030

FWA#: FWA00014155

## Appendix B

### CITI Certificate Hull

		Completion Date 23-Jan-2018 Expiration Date 22-Jan-2021 Record ID 25915478
This is to certify that:		
<b>Hull Marcie</b>		
Has completed the following CITI Program course:		
<b>Social &amp; Behavioral Research - Basic/Refresher</b> (Curriculum Group) <b>Social &amp; Behavioral Research - Basic/Refresher</b> (Course Learner Group) <b>1 - Basic Course</b> (Stage)		
Under requirements set by:		
<b>West Chester University of Pennsylvania</b>		
		 Collaborative Institutional Training Initiative
Verify at <a href="http://www.citiprogram.org/verify/?wcd802f09-5422-4f22-8019-5088b7743359-25915478">www.citiprogram.org/verify/?wcd802f09-5422-4f22-8019-5088b7743359-25915478</a>		

## Appendix C

### Informed Consent

**Project Title:**

**Math Teachers and Nonlinear Learning with Laptops: Narrative Case Studies**

Investigator(s): Marcie Hull; David Backer

**Project Overview:**

Participation in this research project is voluntary and is being done by Marcie Hull as part of their Doctoral Dissertation to determine how public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods. Your participation will take about 4 hours to take 2 questionnaires, and complete 3 interviews. The benefits for the participants will be contributing to current research regarding their math content area. Participants will also contribute to the existing literature surrounding math curriculum methods in project-based schools that use one-to-one laptop programs. This study will add to the existing literature about project-based math curriculum methods. This study will add to the existing literature about one-to-one laptop program math curriculum methods.

The research project is being done by Marcie Hull and David Backer as part of their Doctoral Dissertation to Determine public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods. If you would like to take part, West Chester University requires that you agree and sign this consent form.

You may ask Marcie Hull any questions to help you understand this study. If you don't want to be a part of this study, it won't affect any services from West Chester University. If you choose to be a part of this study, you have the right to change your mind and stop being a part of the study at any time.

1. **What is the purpose of this study?**
  - Determine how public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods.
2. **If you decide to be a part of this study, you will be asked to do the following:**
  - take 2 questionnaires
  - complete 3 interviews
  - This study will take 4 hours of your time.
3. **Are there any experimental medical treatments?**
  - No
4. **Is there any risk to me?**
  - None
5. **Is there any benefit to me?**
  - Benefits to you may include:
    - contributing to current research regarding their math content area
    - contributing to the existing literature surrounding math curriculum methods in project-based schools that use one-to-one laptop programs.
  - Other benefits may include:
    - adding to the existing literature about project-based math curriculum methods
    - adding to the existing literature about one-to-one laptop program math curriculum methods.
6. **How will you protect my privacy?**
  - The session will be recorded.
  - Participants will be recorded during interviews.

- Your records will be private. Only Marcie Hull, David Backer and the IRB will have access to your name and responses.
  - Your name will **not** be used in any reports.
  - Records will be stored:
    - Password Protected File/Computer
  - Records will be destroyed Three Years After Study Completion
7. **Do I get paid to take part in this study?**
- No
8. **Who do I contact in case of research related injury?**
- For any questions with this study, contact:
    - **Primary Investigator:** Marcie Hull at 610-960-5308 or mh893618@wcupa.edu
    - **Secondary Investigator:** David Backer at 610-436-2326 or DBACKER@wcupa.edu
9. **What will you do with my Identifiable Information?**
- Your information will not be used or distributed for future research studies.
  -

For any questions about your rights in this research study, contact the ORSP at 610-436-3557.

I, \_\_\_\_\_ (your name), have read this form and I understand the statements in this form. I know that if I am uncomfortable with this study, I can stop at any time. I know that it is not possible to know all possible risks in a study, and I think that reasonable safety measures have been taken to decrease any risk.

 SIGN HERE

Subject/Participant Signature

Date: \_\_\_\_\_

 SIGN HERE

Witness Signature

Date: \_\_\_\_\_



## Appendix D

### Participating School District Approval to Conduct Study



**Research Review Committee**  
Office of Research and Evaluation  
440 North Broad Street | Suite 214  
Philadelphia, PA 19130

September 10, 2019

Ms. Marcie Hull  
West Chester University  
511 Woodside Ave  
Berwyn, PA 19312

Dear Ms. Hull:

Please allow this letter to serve as notice that The School District of Philadelphia (SDP), through the Office of Research and Evaluation's (ORE) Research Review Committee, has granted you approval to conduct study #2019-08-756, "*Ethnographic Research of Science Leadership Academy Math Teachers in Project Based, One-to-One, Learning Models.*"

In addition, please note:

- This letter is not a data agreement. If you have requested administrative data as part of your RRC proposal, you will receive a draft data agreement to review with additional information including the data we can provide, the conditions for using the data, and the estimated cost. All student data must remain strictly confidential.
- Entry into SDP schools is contingent on the principals' approval. Once a principal has agreed to participate in your study, he/she must complete the *Principal Support to Conduct Research Form* (<http://bit.ly/rrcprincipalsupport>). Please return completed forms to ORE by email ([researchreview@philasd.org](mailto:researchreview@philasd.org)) prior to commencing your project.
- All researchers working in schools must have completed FBI clearance, child abuse history clearance, and criminal record checks. All clearances must be submitted to ORE prior to entering schools.
- You are required to provide a copy of your final report to ORE at the conclusion of your study.

Good luck with your project and feel free to contact us if you have any questions.

Best regards,

---

Joy Lesnick, Ph.D.  
Deputy Chief  
Office of Research and Evaluation

## Appendix E

### Permission to Use Questionnaire - Technology

Re: Permission for Use of Your Survey

Heather Diane Brown <[brown695@live.marshall.edu](mailto:brown695@live.marshall.edu)>

Mon 11/12/2018 8:13 PM

To: Hull, Marcie T. <[MH893618@wcupa.edu](mailto:MH893618@wcupa.edu)>;

Yes feel free to use the survey. Good Luck in your research.

Heather Brown

On Nov 11, 2018, at 6:34 PM, Hull, Marcie T. <[MH893618@wcupa.edu](mailto:MH893618@wcupa.edu)> wrote:

Hi Ms. Brown,

I am writing to ask for permission to use your survey in my upcoming research project. Your survey in "Teachers Attitudes and Confidence in Technology Integration" is exactly what I need to get started with the teachers I will be interviewing.

My background: I am currently a doctoral candidate at West Chester University in Pennsylvania. My study is titled "Ethnographic Research of Math Teachers in Project Based, One-to-One, Learning Models". I plan to begin my research next fall during the 2019-2020 school year. I have been a teacher for almost nineteen years and I have been an instructional technologist for thirteen of those nineteen years.

Thank you for your time.

Sincerely,  
 Marcie Hull, Ed.D. Candidate  
 Ed.D. in Policy, Planning, and Administration  
 College of Education and Social Work  
 West Chester University of Pennsylvania  
 700 South High St, West Chester, PA 19383  
 o. [\(610\)436-1000](tel:(610)436-1000)  
 c. [\(610\)960-5308](tel:(610)960-5308)

## Appendix F

### Permission to Use Questionnaire - Project-Based Learning

#### Re: Permission for Survey and Questionnaire Use

Cristina Petersen <[cristina4202000@yahoo.ca](mailto:cristina4202000@yahoo.ca)>

Sun 12/2/2018 11:43 PM

To: Hull, Marcie T. <[MH893618@wcupa.edu](mailto:MH893618@wcupa.edu)>;

Hi there,

Sorry for the late response. I hardly ever check this email account anymore. May I ask how you got it? Yes, I would be happy to let you use my survey. Could you email any further correspondence to [cristinasuzann@gmail.com](mailto:cristinasuzann@gmail.com)?

I'd love to hear more about your project!

Thanks so much,

Cristina Petersen

[Sent from Yahoo Mail for iPhone](#)

On Saturday, November 24, 2018, 1:35 PM, Hull, Marcie T. <[MH893618@wcupa.edu](mailto:MH893618@wcupa.edu)> wrote:

Hello Ms. Petersen,

I am writing to ask for permission to use your survey in my upcoming research project. Your teacher survey and questionnaire in "Project-based Learning through the Eyes of Teachers and Students: Investigating Opinions of PBL in Adult ESL" is exactly what I need to get started with the teachers I will be interviewing.

My background: I am currently a doctoral candidate at West Chester University in Pennsylvania. My study is titled "Ethnographic Research of Math Teachers in Project Based, One-to-One, Learning Models". I plan to begin my research next fall during the 2019-2020 school year. I have been a teacher for almost nineteen years and I have been an instructional technologist for thirteen of those nineteen years.

Thank you for your time.

Sincerely,

Marcie Hull, Ed.D. Candidate  
Ed.D. in Policy, Planning, and Administration  
College of Education and Social Work  
West Chester University of Pennsylvania  
700 South High St, West Chester, PA 19383  
o.(610) 436-1000  
c.(610) 960-5308

## Appendix G

### Questionnaire Teacher's Attitudes Toward Technology

Susan

**S1. SECTION 1 - Demographic Information**

There are 3 sections to this survey. You do not have to answer any question you are not comfortable with. Thank you for taking your time to complete this survey.

**Q1.**

How many years have you been teaching?

- ☐ 0-5  
☐ 6-10  
☒ 11-15  
☐ 16+

**Q2.**

What degrees, undergraduate and/or graduate have you earned?

BA Psychology MA Physical Education MS Secondary Education

**Q3.** Did you receive any computer or technology course training in college to prepare you for technology use in the classroom?

Yes No

- ☐ ☒

**Q4.**

What technology do you have in your classroom?

Smart board, 1-to-1 laptops, MacBook, iPhone

**Q5.**

What technology do you use for personal use?

MacBook, iPhone

**Q6.** Do you use a hotspot/phone tethering?

Yes No

- ☒ ☐

Q7. Do you use more than one computer at home?

Yes No



Q8. Do you use Amazon's Alexa or Google's Home in your home?

Yes No



Q9. Which one do you use and what went into making that decision?

*This question was not displayed to the respondent.*

Q10. Is this choice purposeful, if so, why?

Yes, I want to minimize the personal information that companies can gather without my permission.

Q11.

What technology do the students have access to at school?

Laptops, smartboards, all of the equipment in our engineering Maker Space and digital video lab

Q12.

Please name some factors that attribute towards your confidence or lack of confidence with using technology in the classroom.

Contribute towards Confidence - having tech-savvy colleagues who are always willing to help; open channel on google chats for Tech Help for SLA; tech coordinator and tech support

Q13.

List the most beneficial technology training you have attended, either preservice or in-service, and what was taught.

Training when I first arrived at SLA - how to manage student concerns through progress monitoring, using Canvas (and Moodle preciously) platform, how to utilize Dropbox, lots of everyday things that made my life as a teacher way easier and made me more efficient

Q14.

	1-Very Confident	2-Confident	3-Unconfident	4-Very Unconfident
computers	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
email	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
internet	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
web browsers	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microsoft Word/Google Docs/Pages	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excel/Spreadsheets/Numbers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PowerPoint/Google Slides/Keynote	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
networking	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
digital cameras	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
interactive whiteboards	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Elmo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
student response systems	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Learning Management Systems	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
text messaging	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
social media	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
cell phones	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
wearables (smart watch/ring)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q38.

Using the following scale please answer Section 3

1- Strongly Agree

2- Agree

3-Disagree

4- Strongly Disagree

	1-Strongly Agree	2-Agree	3-Disagree	4-Strongly Disagree
I feel confident that I understand computer capabilities well enough to maximize them in my classroom.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I have the skills necessary to use the computer for instruction.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can successfully teach relevant subject content with appropriate use of technology.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to evaluate software for teaching and learning.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can use correct computer terminology when directing students using computers.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can help students when they have difficulty with the computer.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can effectively monitor students' computer use for project development in my classroom.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can mentor students in appropriate uses of technology.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I feel confident about assigning and grading technology-based projects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can consistently use educational technology in effective ways.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can provide individual feedback to students during technology use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can regularly incorporate technology into my lessons, when appropriate to student learning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about selecting appropriate technology for instruction based on curriculum standards.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about keeping curricular goals and technology uses in mind when selecting an ideal way to assess student learning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about using technology resources (such as spreadsheets, electronic portfolios, etc.) to collect and analyze data from student tests and products to improve instructional practices.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I am comfortable using technology in my teaching.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can be responsive to students' needs during computer use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that, as time goes by, my ability to address my students' technology needs will continue to improve.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can develop creative ways to cope with system constraints and continue to teach effectively with technology.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to integrate multiple technologies into my instruction.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integrating technology is not pertinent to my curriculum because of the time it takes to create technology-based lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am aware of all the resources available to me to help me successfully integrate technology into the classroom.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The ease of use and access to technology plays a role in the use of it in my classroom.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I use technology for personal use more than classroom use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q39.

Is there anything else you would like to add on technology and your confidence that has not been addressed in this survey?

N/A
-----

Kim

S1. SECTION 1 - Demographic Information

There are 3 sections to this survey. You do not have to answer any question you are not comfortable with.  
Thank you for taking your time to complete this survey.

Q1.

How many years have you been teaching?

- ☒ 0-5  
☐ 6-10  
☐ 11-15  
☐ 16+

Q2.

What degrees, undergraduate and/or graduate have you earned?

B.A. in Mathematics, Masters in Education

Q3. Did you receive any computer or technology course training in college to prepare you for technology use in the classroom?

Yes No

- ☒ ☐

Q4.

What technology do you have in your classroom?

Laptops, Calculators

Q5.

What technology do you use for personal use?

MacBook

Q6. Do you use a hotspot/phone tethering?

Yes No

- ☐ ☒



Q7. Do you use more than one computer at home?

Yes No



Q8. Do you use Amazon's Alexa or Google's Home in your home?

Yes No



Q9. Which one do you use and what went into making that decision?

Alexa, it was a gift

Q10. Is this choice purposeful, if so, why?

No.

Q11.

What technology do the students have access to at school?

Chromebook, internet, Canvas Course site

Q12.

Please name some factors that attribute towards your confidence or lack of confidence with using technology in the classroom.

Fairly confident because I have a lot of experience using a laptop and I used Canvas for my masters program.

Q13.

List the most beneficial technology training you have attended, either preservice or in-service, and what was taught.

I took an Excel course called Computers in Management in college that I still find useful to this day. Setting up formulas in sheets, mail merging, etc.

Q14.

How do you feel about technology training?

I have not attended a lot of technology training.

Q15.

What do you think would help you the most with technology integration in the classroom?

More opportunities with people coming into school to train me.

Q16.

Do you feel you have been offered enough technology training either preservice or in-service?

Yes No



## S2. SECTION 2

Q17. Please check the box of your confidence level in using the following for CLASSROOM USE:

	1-Very Confident	2-Confident	3-Unconfident	4-Very Unconfident
computers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
email	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
internet	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
web browsers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microsoft Word/Google Docs/Pages	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excel/Spreadsheets/Numbers	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
PowerPoint/Google Slides/Keynote	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
networking	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
digital cameras	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interactive Whiteboard	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Elmo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
student response systems	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
learning management system	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
text messaging	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
social media	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
cell phones	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
wearables (smart watch/ring)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

Q18. Please check the box of your confidence level in using the following for PERSONAL USE:

	1-Very Confident	2-Confident	3-Unconfident	4-Very Unconfident
computers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
email	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
internet	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
web browsers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microsoft Word/Google Docs/Pages	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excel/Spreadsheets/Numbers	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
PowerPoint/Google Slides/Keynote	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
networking	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
digital cameras	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
interactive whiteboards	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Elmo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
student response systems	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Learning Management Systems	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
text messaging	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
social media	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
cell phones	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
wearables (smart watch/ring)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q38.

Using the following scale please answer Section 3

1- Strongly Agree

2- Agree

3-Disagree

4- Strongly Disagree

	1-Strongly Agree	2-Agree	3-Disagree	4-Strongly Disagree
I feel confident that I understand computer capabilities well enough to maximize them in my classroom.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I have the skills necessary to use the computer for instruction.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can successfully teach relevant subject content with appropriate use of technology.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to evaluate software for teaching and learning.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can use correct computer terminology when directing students using computers.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can help students when they have difficulty with the computer.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

I feel confident I can effectively monitor students' computer use for project development in my classroom.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can mentor students in appropriate uses of technology.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about assigning and grading technology-based projects.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can consistently use educational technology in effective ways.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can provide individual feedback to students during technology use.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can regularly incorporate technology into my lessons, when appropriate to student learning.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about selecting appropriate technology for instruction based on curriculum standards.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I feel confident about keeping curricular goals and technology uses in mind when selecting an ideal way to assess student learning.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about using technology resources (such as spreadsheets, electronic portfolios, etc.) to collect and analyze data from student tests and products to improve instructional practices.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I am comfortable using technology in my teaching.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can be responsive to students' needs during computer use.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that, as time goes by, my ability to address my students' technology needs will continue to improve.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I feel confident that I can develop creative ways to cope with system constraints and continue to teach effectively with technology.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to integrate multiple technologies into my instruction.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integrating technology is not pertinent to my curriculum because of the time it takes to create technology-based lessons.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I am aware of all the resources available to me to help me successfully integrate technology into the classroom.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
The ease of use and access to technology plays a role in the use of it in my classroom.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
I use technology for personal use more than classroom use.	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

---

Is there anything else you would like to add on technology and your confidence that has not been addressed in this survey?

## Adam

### S1. SECTION 1 - Demographic Information

There are 3 sections to this survey. You do not have to answer any question you are not comfortable with. Thank you for taking your time to complete this survey.

Q1.

How many years have you been teaching?

- ☐ 0-5  
☒ 6-10  
☐ 11-15  
☐ 16+

Q2.

What degrees, undergraduate and/or graduate have you earned?

BSME, MSME (Mechanical Engineering)

Q3. Did you receive any computer or technology course training in college to prepare you for technology use in the classroom?

Yes No



Q4.

What technology do you have in your classroom?

Extensive. PC Laptops, Projector, Smartboard, Audio System, 3D printers, laser cutter, machine shop, woodshop, etc.

Q5.

What technology do you use for personal use?

MacBook Pro, iPhone, Pocket Protector

Q6. Do you use a hotspot/phone tethering?

Yes No



Q7. Do you use more than one computer at home?

Yes No



Q8. Do you use Amazon's Alexa or Google's Home in your home?

Yes No



Q9. Which one do you use and what went into making that decision?

Um, what was the question on the previous page? I think it was google classroom or something else? Our school uses Google Enterprise, Canvas, and Slate, along with a few more tools. We use Canvas to manage our class assignments and grading. I wasn't here when these decisions were made, but the results are excellent.

Q10. Is this choice purposeful, if so, why?

Sorry, fuzzy on what you are asking from previous page...

Q11.

What technology do the students have access to at school?

1:1 laptops (ChromeBooks), smartphones, all our apps, principally, Canvas and Google Enterprise.

Q12.

Please name some factors that attribute towards your confidence or lack of confidence with using technology in the classroom.

I am highly confident using the technology I have. Mostly comes from my technical training and energy around technology. I focus on continuous improvement for my own workflow and that of our organization, so mastering technologies is essential.

Q13.

List the most beneficial technology training you have attended, either preservice or in-service, and what was taught.

Our school is very technology-savvy. During our first week of PD each week, we review all the technologies available to us and best practices around workflow that staff have developed over time. These are critically important to me.

Q14.

How do you feel about technology training?

Great! Especially when educators are running them.

Q15.

What do you think would help you the most with technology integration in the classroom?

Best practices by practitioners. I can implement the solutions into my work, but like to see more ideas of what works best.

Q16.

Do you feel you have been offered enough technology training either preservice or in-service?

Yes No



## S2. SECTION 2

Q17. Please check the box of your confidence level in using the following for CLASSROOM USE:

	1-Very Confident	2-Confident	3-Unconfident	4-Very Unconfident
computers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
email	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
internet	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
web browsers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microsoft Word/Google Docs/Pages	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excel/Spreadsheets/Numbers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PowerPoint/Google Slides/Keynote	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
networking	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
digital cameras	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interactive Whiteboard	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Elmo	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
student response systems	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
learning management system	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
text messaging	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
social media	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
cell phones	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
wearables (smart watch/ring)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q18. Please check the box of your confidence level in using the following for PERSONAL USE:

	1-Very Confident	2-Confident	3-Unconfident	4-Very Unconfident
computers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
email	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
internet	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
web browsers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microsoft Word/Google Docs/Pages	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excel/Spreadsheets/Numbers	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PowerPoint/Google Slides/Keynote	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
networking	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
digital cameras	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
interactive whiteboards	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Elmo	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
student response systems	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Learning Management Systems	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
text messaging	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
social media	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
cell phones	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
wearables (smart watch/ring)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q38.

Using the following scale please answer Section 3

1- Strongly Agree

2- Agree

3-Disagree

4- Strongly Disagree

	1-Strongly Agree	2-Agree	3-Disagree	4-Strongly Disagree
I feel confident that I understand computer capabilities well enough to maximize them in my classroom.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I have the skills necessary to use the computer for instruction.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can successfully teach relevant subject content with appropriate use of technology.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to evaluate software for teaching and learning.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can use correct computer terminology when directing students using computers.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can help students when they have difficulty with the computer.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



I feel confident I can effectively monitor students' computer use for project development in my classroom.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can mentor students in appropriate uses of technology.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about assigning and grading technology-based projects.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can consistently use educational technology in effective ways.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can provide individual feedback to students during technology use.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can regularly incorporate technology into my lessons, when appropriate to student learning.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about selecting appropriate technology for instruction based on curriculum standards.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about keeping curricular goals and technology uses in mind when selecting an ideal way to assess student learning.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident about using technology resources (such as spreadsheets, electronic portfolios, etc.) to collect and analyze data from student tests and products to improve instructional practices.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I am comfortable using technology in my teaching.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident I can be responsive to students' needs during computer use	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that, as time goes by, my ability to address my students' technology needs will continue to improve.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I can develop creative ways to cope with system constraints and continue to teach effectively with technology.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to integrate multiple technologies into my instruction.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integrating technology is not pertinent to my curriculum because of the time it takes to create technology-based lessons.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I am aware of all the resources available to me to help me successfully integrate technology into the classroom.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The ease of use and access to technology plays a role in the use of it in my classroom.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I use technology for personal use more than classroom use.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Q39.

Is there anything else you would like to add on technology and your confidence that has not been addressed in this survey?

## Appendix H

### Questionnaire Teacher's Attitudes Toward Project-Based Learning

Susan

**Q26. Welcome to the research study!**

Project Title: Math Teachers and Nonlinear Learning with Laptops: Narrative Case Studies

Investigators: Marcie Hull, David Backer

Marcie T. Hull

Art Teacher

Science Leadership Academy Middle School

Ph#: 610-960-5308

MH893618@wcupa.edu

David Backer, Ph.D.

Educational and Policy Studies

West Chester University

Ph#: 610-436-2326

DBACKER@wcupa.edu

Project Overview:

Participation in this research project is voluntary and is being done by Marcie Hull as part of their Doctoral Dissertation to determine how public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods. Your participation will take about 4 hours to take 2 questionnaires, and complete 3 interviews. The benefits for the participants will be contributing to current research regarding their math content area. Participants will also contribute to the existing literature surrounding math curriculum methods in project-based schools that use one-to-one laptop programs. This study will add to the existing literature about project-based math curriculum methods. This study will add to the existing literature about one-to-one laptop program math curriculum methods.

The research project is being done by Marcie Hull and David Backer as part of their Doctoral Dissertation to Determine public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods. If you would like to take part, West Chester University requires that you agree and sign this consent form.

You may ask Marcie Hull any questions to help you understand this study. If you don't want to be a part of this study, it won't affect any services from West Chester University. If you choose to be a part of this study, you have the right to change your mind and stop being a part of the study at any time.

**What is the purpose of this study?**

Determine how public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods.

If you decide to be a part of this study, you will be asked to do the following: take 2 questionnaires complete 4 interviews This study will take 4-6 hours of your time.

**Are there any experimental medical treatments?**

No

**Is there any risk to me?**

None

**Is there any benefit to me?**

Benefits to you may include: contributing to current research regarding their math content area contributing to the existing literature surrounding math curriculum methods in project-based schools that use one-to-one laptop programs. Other benefits may include: adding to the existing literature about project-based math curriculum methods adding to the existing literature about one-to-one laptop program math curriculum methods.

**How will you protect my privacy?**

The session will be recorded. Participants will be recorded during interviews. Your records will be private. Only Marcie Hull, David Backer, and the IRB will have access to your name and responses. Your name will not be used in any reports. Records will be stored: Password Protected File/Computer Records will be destroyed Three Years After Study Completion

**Do I get paid to take part in this study?**

No

**Who do I contact in case of research-related injury?**

For any questions with this study, contact: Primary Investigator: Marcie Hull at 610-960-5308 or mh893618@wcupa.edu Secondary Investigator: David Backer at 610-436-2326 or DBACKER@wcupa.edu

**What will you do with my Identifiable Information?**

Your information will not be used or distributed for future research studies.

For any questions about your rights in this research study, contact the ORSP at 610-436-3557.

***I have read this form and I understand the statements in this form. I know that if I am uncomfortable with this study, I can stop at any time. I know that it is not possible to know all possible risks in a study, and I think that reasonable safety measures have been taken to decrease any risk.***

*By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.*

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

- ☒ I consent, begin the study
- ☐ I do not consent, I do not wish to participate

Q1. What is your definition of a project?

*This question was not displayed to the respondent.*

Q2. What are some examples of projects you have done in your classes this semester?

*This question was not displayed to the respondent.*

Q3. In your opinion, what are the goals of project-based learning?

*This question was not displayed to the respondent.*

Q4. To what extent do you try to implement or use projects in your classroom?

*This question was not displayed to the respondent.*

Q5. What strategies do you use to implement a project?

*This question was not displayed to the respondent.*

Q6. Do you think project-based learning is effective? Why or why not?

*This question was not displayed to the respondent.*

Q7. In your opinion, how long should a project typically take?

*This question was not displayed to the respondent.*

Q8. How do you compare a project-based approach with traditional teaching?

*This question was not displayed to the respondent.*

Q9. What is your opinion of getting the students to help plan a project?

*This question was not displayed to the respondent.*

Q10. In your opinion, what are the advantages and disadvantages of using project-based learning in the classroom?

*This question was not displayed to the respondent.*

Q11. What do you think are the challenges in organizing a project in your class?

*This question was not displayed to the respondent.*

Q12. What are some constraints which may prohibit you from implementing a project-based approach?

*This question was not displayed to the respondent.*

Q13. Do you have any other comments to add about Project-based Learning or teaching in general?

*This question was not displayed to the respondent.*

Q14.

How long have you worked at your current school?

*This question was not displayed to the respondent.*

Q15. How many hours of class a week do you teach at your current school?

*This question was not displayed to the respondent.*

Q16.

Approximately how many hours a week (on average) do you spend planning for the classroom?

*This question was not displayed to the respondent.*

Q17.

How many years have you been teaching Math?

*This question was not displayed to the respondent.*

Q18. What Math level(s) have you taught before your current school?

*This question was not displayed to the respondent.*

Q19.

What Math level(s) do you currently teach at this school?

*This question was not displayed to the respondent.*

Q22. Click to write the question text

*This question was not displayed to the respondent.*

Kim

**Q26. Welcome to the research study!**

**Project Title:** Math Teachers and Nonlinear Learning with Laptops: Narrative Case Studies

**Investigators:** Marcie Hull; David Backer

Marcie T. Hull

Art Teacher

Science Leadership Academy Middle School

Ph#: 610-960-5308

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The research project is being done by Marcie Hull and David Backer as part of their Doctoral Dissertation to Determine public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods. If you would like to take part, West Chester University requires that you agree and sign this consent form.

You may ask Marcie Hull any questions to help you understand this study. If you don't want to be a part of this study, it won't affect any services from West Chester University. If you choose to be a part of this study, you have the right to change your mind and stop being a part of the study at any time.

**What is the purpose of this study?**

Determine how public school mathematics teachers using one to one laptop programs to guide urban students through project-based teaching methods.

If you decide to be a part of this study, you will be asked to do the following: take 2 questionnaires complete 4 interviews This study will take 4-6 hours of your time.

**Are there any experimental medical treatments?**

No

**Is there any risk to me?**

None

**Is there any benefit to me?**

Benefits to you may include: contributing to current research regarding their math content area contributing to the existing literature surrounding math curriculum methods in project-based schools that use one-to-one laptop programs. Other benefits may include: adding to the existing literature about project-based math curriculum methods adding to the existing literature about one-to-one laptop program math curriculum methods.

**How will you protect my privacy?**

The session will be recorded. Participants will be recorded during interviews. Your records will be private. Only Marcie Hull, David Backer, and the IRB will have access to your name and responses. Your name will not be used in any reports. Records will be stored: Password Protected File/Computer Records will be destroyed Three Years After Study Completion

**Do I get paid to take part in this study?**

No

**Who do I contact in case of research-related injury?**

For any questions with this study, contact: Primary Investigator: Marcie Hull at 610-960-5308 or mh893618@wcupa.edu Secondary Investigator: David Backer at 610-436-2326 or DBACKER@wcupa.edu

**What will you do with my Identifiable Information?**

Your information will not be used or distributed for future research studies.

For any questions about your rights in this research study, contact the ORSP at 610-436-3557.

***I have read this form and I understand the statements in this form. I know that if I am uncomfortable with this study, I can stop at any time. I know that it is not possible to know all possible risks in a study, and I think that reasonable safety measures have been taken to decrease any risk.***

*By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.*

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

- ☒ I consent, begin the study
- ☐ I do not consent, I do not wish to participate

Q1. What is your definition of a project?

A project is a long-term activity that involves an end product in which multiple applications of knowledge are used.

Q2. What are some examples of projects you have done in your classes this semester?

For their 9th grade Algebra Project, students will work in groups to analyze various data values related to the school district of Philadelphia. Based on their analysis, they will then develop recommendations for improvement and pitch their ideas to the class.

Q3. In your opinion, what are the goals of project-based learning?

The goals of project-based learning are to engage students in an applicable form of the content we have covered in class. Here, they also learn the soft skills required for life like collaboration and presentation.

Q4. To what extent do you try to implement or use projects in your classroom?

At least one major project per quarter in each course.

Q5. What strategies do you use to implement a project?

Giving students rubrics ahead of time help them know what I am looking for as well as make me clear to myself of the expectations.

Q6. Do you think project-based learning is effective? Why or why not?

---

I believe that project-based learning is effective in showing students the applications of their knowledge as well as having them create a memorable product that they can be proud of. I do think it requires more time to deliver content than some other methods.

---

Q7. In your opinion, how long should a project typically take?

---

No longer than two weeks, sometimes only one week.

---

Q8. How do you compare a project-based approach with traditional teaching?

---

For me, a traditional teaching model is based on a cycle of receiving content, memorizing content, and then reciting that content. A project-based model relies on students consuming and applying all of their previous knowledge to particular content and then creating something that is valuable to them.

---

Q9. What is your opinion of getting the students to help plan a project?

---

I believe students need scaffolding depending on their experience with projects. Chunking major projects in order to check-in and provide feedback is especially essential for younger students.

---

Q10. In your opinion, what are the advantages and disadvantages of using project-based learning in the classroom?

---

The advantages are that students are able to bring their unique talents and experiences to the classroom in a way that the products they create are truly unique. The challenges in the math classroom can be students getting too focused on a particular element (i.e. the presentation) and not demonstrating enough mathematical knowledge.

---

Q11. What do you think are the challenges in organizing a project in your class?

---

Organizing a project can be challenging due to different group dynamics and work ethics. I never want a single student taking over for a group and feeling they have to do all of the work in order to get the grade that they want.

---

---

Q12. What are some constraints which may prohibit you from implementing a project-based approach?

Time. Especially in Algebra which has a high-stakes standardized test at the end of it, I can't spend too much time on one specific topic.

Q13. Do you have any other comments to add about Project-based Learning or teaching in general?

Q14.  
How long have you worked at your current school?

5 years

Q15. How many hours of class a week do you teach at your current school?

21 Hours

Q16.  
Approximately how many hours a week (on average) do you spend planning for the classroom?

18

Q17.  
How many years have you been teaching Math?

5

Q18. What Math level(s) have you taught before your current school?

N/A

Q19.  
What Math level(s) do you currently teach at this school?



Algebra, Geometry, Calculus

Q22. Click to write the question text

	1-strongly disagree	2-disagree	3-slightly disagree	4-partly agree	5-agree	6-strongly agree
I like the students to determine topics for discussion when I assign group work.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like to use activities that encourage reflection.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like to use group work which is focused on a theme or is project-based.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I like to use a variety of materials in addition to textbooks.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like students to experience hands-on and real life tasks or activities which involve going outside the classroom.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I like it when my classes are focused on content and an ongoing theme rather than individual linguistics items or skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I like it when my class produces a final product.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I like it when I assume different roles in class, (e.g., facilitator, sharing, and/or instructor).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I like it when students have to assume different roles as well (e.g., manager, actor, writer, secretary, teacher, and/or researcher).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
I like students to work on a project for more than a single class session.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Adam

Yes, highly effective. It prepares students for life after college, which is mostly based on collaborative projects. When designed and executed correctly, PBL connects kids into learning in ways that textbooks, worksheets, and tests don't (at least for many students I teach). My son went to SLA, so I have a unique perspective about how it changed his life.

Q7. In your opinion, how long should a project typically take?

My projects range from a few weeks to a few months. I have tried whole-year projects, but they provide challenges in maintaining momentum.

Q8. How do you compare a project-based approach with traditional teaching?

I think I addressed that earlier, but adding... I think traditional teaching is the default mode that comes without deep planning. A person has knowledge and wants to relay it to another. We speak that knowledge and expect the student to learn it. We test that knowledge by asking for it to be regurgitated back, and if lucky, extended to new uses. In PBL, we ask students to learn through doing. Teachers become learning coaches, not lecturers. Assessments are done through analyzing projects against well-design and communicated rubrics.

Q9. What is your opinion of getting the students to help plan a project?

I try to do this whenever I can. I build to this over the four years I teach my students, finishing with senior engineering, where students lead most of the class, and I am their learning coach.

Q10. In your opinion, what are the advantages and disadvantages of using project-based learning in the classroom?

See answers to "How do you compare a project-based approach with traditional teaching".

Q11. What do you think are the challenges in organizing a project in your class?

Projects can be challenging for an engineering teacher. They often involve a number of phases; ideation, design, construction, iteration, etc... They frequently require materials and skills that my students have yet to master. They have safety concerns. They also are typically multi-step with interdependencies between tasks, requiring a good deal of coordination and scheduling. Many of the challenges of projects are also learning opportunities for my students. Thus, my engineers graduate understanding how to develop Gantt Charts and Action Item Lists, etc.

---

Q12. What are some constraints which may prohibit you from implementing a project-based approach?

I don't have many constraints on me - I am very fortunate. I have agency in what and how I decide to teach. I have a supportive principal who values my teaching approach. I have sufficient funding through my personal fundraising to conduct our work. The biggest active constraint for me is calendar and classroom time. Projects require a lot of class time - especially if significant construction is involved. And especially since these projects are often the largest pieces of work my students have ever done.

Q13. Do you have any other comments to add about Project-based Learning or teaching in general?

I feel very fortunate to be in a school and to have a principal that deeply understands and supports this kind of learning.

Q14.  
How long have you worked at your current school?

5 years

Q15. How many hours of class a week do you teach at your current school?

I teach about 20 hours a week in the class. I also teach many hours at our afterschool engineering and robotics club.

Q16.  
Approximately how many hours a week (on average) do you spend planning for the classroom?

You are asking about "Planning" not all outside of class time. So, I would say about 20 hours.

Q17.  
How many years have you been teaching Math?

I have taught engineering for 5 years.

Q18. What Math level(s) have you taught before your current school?

This is my first assignment

Q19.  
What Math level(s) do you currently teach at this school?

I teach engineering to grades 9-12
------------------------------------

Q22. Click to write the question text

	1-strongly disagree	2-disagree	3-slightly disagree	4-partly agree	5-agree	6-strongly agree
I like the students to determine topics for discussion when I assign group work.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like to use activities that encourage reflection.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like to use group work which is focused on a theme or is project-based.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like to use a variety of materials in addition to textbooks.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like students to experience hands-on and real life tasks or activities which involve going outside the classroom.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like it when my classes are focused on content and an ongoing theme rather than individual linguistics items or skills.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like it when my class produces a final product.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like it when I assume different roles in class, (e.g., facilitator, sharing, and/or instructor).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like it when students have to assume different roles as well (e.g., manager, actor, writer, secretary, teacher, and/or researcher).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
I like students to work on a project for more than a single class session.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

## Appendix I

### Freeman School Algebra 2 Rubric Example - Social Justice

ALGEBRA 2 – Viewing Issues of Social Justice through a Mathematical Lens

	Exceed Expectations 20-19	Meet Expectations 18-16	Approaches Expectations 15-13	Does NOT Meet Expectations 12-0
<b>Design</b> (Planning; organization; research; understanding of project)		Thoughtful and careful planning. Good understanding of purpose of the project. Written analysis and PSA illustrate the findings of the social justice topic and evaluate data through a mathematical lens. The main insights are conveyed clearly.		
<b>Knowledge</b> (Research; understanding of concepts; use of correct terms, formulas, and diagrams)		Research is thorough, and key ideas and details are selected with care. All sources are cited. Calculates measures of central tendency (mean, median, mode, range, quartiles, IQR) and at least 2 original %-based statements about data.		
<b>Application</b> (Understanding of real-life applications)		Analysis is thorough for each of data sets. Analyze at least one aspect of data in terms of central tendency. Analyze at least one aspect of the data in terms of both probability and odds (included independent & dependent probability). Developed components for an action plan & discussion about how graph/visuals might change if interventions implemented.		
<b>Process</b> (Collaboration; fulfillment of project deadlines and requirements; reflection)		All parts of the project, including written analysis and PSA are completed on time and meet the necessary requirements. Different parts of the project are thoughtfully coordinated among group members. Good use of in-class work time.	Group: 10 points Individual: 10 points	
<b>Presentation</b> (Communication of ideas and concepts; sense of audience engagement)		Presentation is well planned and designed, clear, and informative. Good attention to details (timing, visual aids, flow of information, audience engagement) in both the analysis & videos. Oral & written communication is error-free, clear, and accurate.	PSA: 10 points Written report: 10 points	

**Table 2**

*The Freeman School Rubric*

	Design	Knowledge	Application	Presentation	Process
<b>Exceeds expectations</b>					
<b>Meets expectations</b>					
<b>Approaches expectations</b>					
<b>Does not meet expectations</b>					

(Laufenberg, & Lehmann, 2012)

## Appendix J

### Freeman School UBD- Algebra 2 - Social Justice

STAGE 1: Desired Results		
	Transfer	
Unit Goals	<p><i>Students will be able to independently use their learning to...</i></p> <ul style="list-style-type: none"> <li>• Introduce the ideas of empirical and theoretical probability.</li> <li>• Explain the difference between a fair and biased object.</li> <li>• Draw a distinction between permutations and combinations, highlighting that order is or is not important to distinguish which to use to calculate the probability of two or more activities occurring at the same time.</li> <li>• Know how to use context clues in a word problem to identify if replacement of objects does or does not occur in a probability event.</li> <li>• Explain the difference between representations of data and how each can be used with discussions of central tendency (mean, median, mode).</li> <li>• Differentiate between probability and odds.</li> <li>• Use measures of central tendency and statistics</li> </ul>	
	Meaning	
	<p>Understandings (<i>What specifically should students be able to understand after completing the unit?</i>)</p>	<p>Essential Questions (<i>What thought-provoking questions will foster meaning-making, inquiry and transfer?</i>)</p>

	<ul style="list-style-type: none"> <li>• Probability and chance are linked to everyday phenomena</li> <li>• Probability spans from impossibility to uncertainty to certainty</li> <li>• Probability is represented as a fraction between 0 and 1 inclusively</li> <li>• Order matters depending on the circumstances of a problem</li> <li>• Probability does not always translate to reality</li> <li>• Measures of central tendency and spread can be used to analyze sets of data</li> <li>• There are many different ways to represent sets of data, and there are different advantages to each method</li> <li>• Regression lines and best-fit models can be used to make predictions about sets of data</li> <li>• Technology is a very powerful tool for data analysis, and can be used to help make predictions and generate graphical representations</li> </ul>	<ul style="list-style-type: none"> <li>• Can we say with certainty that an event will occur? Can we say with certainty that an event occurring is impossible? For any probability claim, what is our supporting evidence?</li> <li>• How are prediction and probability linked/related, if at all?</li> <li>• Why is calculating the likelihood of an event occurring significant? How would our lives be different if we did not take chance into account?</li> <li>• Why are measures of central tendency and spread significant to data analysis?</li> <li>• In what ways can data sets be represented? What are the advantages of various representation techniques?</li> <li>• How can technology be used to help in data analysis?</li> <li>• How can models be used along with data sets to make predictions?</li> </ul>
Established Goals	Acquisition of Knowledge and Skill	
	<p>Students will know... (What facts and basic concepts should students know and be able to recall?)</p> <ul style="list-style-type: none"> <li>• How probability and statistics are related</li> <li>• How to calculate many simple theoretical probability problems (coin toss, dice roll, card draw, etc.)</li> <li>• How to make predictions using</li> </ul>	<p>Students will be skilled at... (What skills and processes should students be able to draw upon and use?)</p> <ul style="list-style-type: none"> <li>• Conceptualize uncertainty in real world events, realizing that precision is not always guaranteed by mathematics when applied to everyday situations.</li> </ul>

	<p>patterns found in data analysis</p> <ul style="list-style-type: none"> <li>• How to calculate measures of central tendency</li> </ul>	<ul style="list-style-type: none"> <li>• Evaluate simple probabilities applied to fair objects using the theoretical rule.</li> <li>• Calculate the probabilities of compound events using counting and sets, the counting principle, tree diagrams, listing ordered elements, and graphing.</li> <li>• Define and evaluate permutations and combinations using factorials notation and formulas.</li> <li>• Solve probability problems in which items are chosen at random either with or without replacement.</li> <li>• Measure central tendency (mean, median, mode)</li> <li>• Represent data sets using histograms, stem-and-leaf plots and box-and-whisker plots.</li> </ul>
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STAGE 2: Evidence	
Evaluative Criteria	Assessment Evidence
<p>Performance is judged in terms of...</p> <p><i>(What criteria will be used in each assessment to evaluate attainment of desired results?)</i></p>	<p>Transfer Task(s)</p> <p>(What assessment(s) and/or project(s) will provide understanding and meet other Stage 1 goals?)</p> <ul style="list-style-type: none"> <li>• Standards-based quizzes assessing student progress in learning specific course content (see list of specific standards below).</li> <li>• Small group problems/graphing investigations in class focused on exploring key course concepts.</li> <li>• 4th quarter benchmark project: using probability and statistics to analyze a social justice topic (see project description)</li> </ul> <p>Other Evidence</p> <p>(What other evidence will be collected and evaluated to ensure that Stage 1 goals have been met?)</p> <ul style="list-style-type: none"> <li>• Daily presentation of solutions to warm-up problems.</li> </ul>



	<ul style="list-style-type: none"> <li>Nightly homework assignments to practice skills learned in class.</li> </ul>
Inquiry (How will this unit help students generate their own questions?)	<p>What are probability and odds?</p> <p>How can concepts of probability be used to influence decisions?</p> <p>How can data be explained and analyzed?</p>
Research (When and how will students search for information during this unit?)	Students will research various social justice-themed topics.
Collaboration (When will students be working together during this unit?)	<p>Work with partners on classwork activities, problems, and assignments.</p> <p>Collaborate with a group on benchmark project with the goal of writing a formal paper and creating a video focused on a social justice-themed topics.</p>
Presentation (How will students be displaying their work and to whom?)	<p>Students present warm-up problems, solutions to homework assignments, and classwork problems.</p> <p>Benchmark project is presented as a formal paper, as well as a video PSA.</p>
Reflection (When will students be able to look back upon their work and their learning?)	Students will engage in group reflection by scoring and giving feedback to themselves and each other.

[SCHOOL] Standards-Based Reporting	
Subject-Specific Standard (Which departmental standards will this unit address?)	Assessment or Task Evaluating Standard (Which assignments will be used for assessing students' progress?)
A-Computation and operations-- Students can perform computational and algebraic operations to the appropriate level of course.	<ul style="list-style-type: none"> <li>Standards-based quizzes assessing specific course content linked to computation and operations.</li> <li>Warm-up and classwork problems focused on computation with exponential functions.</li> <li>Benchmark project involving calculations with central tendency, probability, and odds.</li> </ul>

B-Visual-- Students can visually represent mathematical situations through graphs and diagrams.	<ul style="list-style-type: none"> <li>Standards-based quizzes assessing specific course content linked to visual representation of mathematical concepts.</li> <li>Benchmark project requiring students to create visualizations of data.</li> </ul>
C-Verbal and written communication skills-- Students can clearly communicate mathematical problem-solving process.	<ul style="list-style-type: none"> <li>Standards-based quizzes assessing specific course content linked to verbal and written communication.</li> <li>Written and verbal explanations of problem-solving process during warm-ups and homework assignments.</li> <li>Formal written project as 4th quarter benchmark.</li> </ul>
D-Problem solving- Choose and apply various problem-solving strategies to model and solve a wide variety of problems.	<ul style="list-style-type: none"> <li>Standards-based quizzes assessing specific course content linked to problem-solving.</li> <li>Problems involving applications of probability and odds.</li> <li>Benchmark project involving analyzing/addressing social justice-themed issues.</li> </ul>

Reading Strategies	
Strategies  <i>(What strategies will be used to improve reading comprehension and access to information?)</i>	Activities  <i>(Which assignments will incorporate these reading across the curriculum strategies?)</i>
Students will regularly be asked to write explanations of their problem solving processes.	Several standards based assessments will focus on the written explanation of problem solving.
Students will present to the class regularly, verbally explaining their problem	Daily warm up problems where different students will explain their problem

solving processes.	<p>solving process to the whole class.</p> <p>Small group assignments where students will explain concepts to their peers in their group.</p>
Students will write a written report for their benchmark.	Benchmark project.

**Department Standards:**

A-Computation and operations--Students can perform computational and algebraic operations to the appropriate level of course.

B-Visual-- Students can visually represent mathematical situations through graphs and diagrams.

C-Verbal and written communication skills-- Students can clearly communicate mathematical problem-solving process.

D-Problem solving- Choose and apply various problem-solving strategies to model and solve a wide variety of problems.

**Unit 6 Standards: Probability and Statistics**

52. Create box-whisker and stem-leaf plots to visualize data. (B)

53. Calculate measures of central tendency (mean, median, mode, quartiles, range, IQR. (A)

54. Differentiate between probability and odds. (C)

55. Solve problems involving probability and odds. (D)

56. Solve problems involving counting. (D)

57. Solve possible outcome problems involving permutations and combinations. (D)

### **Standards of Mathematical Practices**

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others
- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning

### **Core Standards:**

CC.2.1.HS.F.3- Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays. CC.2.1.HS.F.5- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

CC.2.2.HS.D.1- Interpret the structure of expressions to represent a quantity in terms of its context.

C.2.4.HS.B.1- Summarize, represent, and interpret data on a single count or measurement variable.

CC.2.4.HS.B.2- Summarize, represent, and interpret data on two categorical and quantitative variables.

CC.2.4.HS.B.5- Make inferences and justify conclusions based on sample surveys, experiments, and observational studies

CC.2.4.HS.B.6- Use the concepts of independence and conditional probability to

interpret data.

## Appendix K

### Participant 4 - Decline



Marcie Hull <XXX@gmail.com>

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#### Research Interviews - Please Reply

2 messages

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**Marcie T. Hull** <mhull@sXXX.org>

Thu, Oct 17, 2019 at 8:41 PM

To: Participant 4 <PARTICIPANT4@sXXX.org>

Hi Participant 4,  
Did you want to be a part of this dissertation? You are by no means required to stay in as a participant. Did you want to schedule the first interview or should I stop contacting you?  
Please let me know at your earliest convenience,  
Marcie

---

**Participant 4** <PARTICIPANT4@XXX.org> To: "Marcie T. Hull" <mhull@sXXX.org>

Mon, Oct 21, 2019 at 12:45 PM

Hi Marcie,

I'm so sorry. I'm so overwhelmed with this school year. Please find someone else.

Sorry,  
Participant 4

--

Participant 4  
Mathematics and Computer Science Teacher  
Freeman School

## Appendix L

### Introduction to Engineering UBD

## Introduction to Engineering

### Overview

This course is designed for the 9th grade level and is taught twice a week for half a year. Thus, it is designed for two quarters of 16 classes each - classes are 65 minutes long. This course has no prerequisites and does not assume that students have any experience in engineering, design, or fabrication. This course is a prerequisite for a 3-year study in engineering.

### Stage 1 – Desired Results

Established Goals:
<p><b>The purpose of this course:</b></p> <ul style="list-style-type: none"> <li>• For students to gain a basic understanding of the engineering design process and design thinking</li> <li>• For students to develop skills in solving problems using the engineering process</li> <li>• For students to learn and practice effective collaborative group work</li> <li>• For students to become familiar with the safe use of hand tools and basic hand power tools</li> </ul> <p><b>Through the study in this course, students will gain understanding and skills in these areas as outlined in the NGSS:</b></p> <p><b>Performance Expectations</b></p> <p><b>HS-ETS1-2:</b> Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</p> <p><b>HS-ETS1-3:</b> Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs</p> <p><b>Disciplinary Core Ideas</b></p>

**ETS1.A:** Defining and Delimiting Engineering Problems

**ETS1.B:** Developing Possible Solutions

**ETS1.C:** Optimizing the Design Solution

### Crosscutting Concepts

**2: Cause and Effect** - Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

**4: Systems and System Models** - A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

**6: Structure and Function** - The way an object is shaped or structured determines many of its properties and functions.

Students will understand that:	Essential Questions:
<ul style="list-style-type: none"> <li>• Safety is paramount in the shop and safety procedures must be followed at all times</li> <li>• The made world is highly designed</li> <li>• The form of a designed object follows its function</li> <li>• Brainstorming well is based on a set of best practices</li> <li>• The engineering design process is universal to problem solving</li> <li>• You should expect to fail during</li> </ul>	<ol style="list-style-type: none"> <li>1. In what ways are engineering and science similar and different?</li> <li>2. How can we know how well the form of an object follows its function?</li> <li>3. Why is the engineering design process cyclical?</li> <li>4. In what ways do engineers utilize the</li> </ol>



<p>engineering in the beginning</p> <ul style="list-style-type: none"> <li>• Good engineers fail quickly and learn from their failures</li> <li>• Engineering is an iterative process - fast iterations are the key</li> <li>• Engineers build on the work of others - research is essential</li> <li>• A design or solution is meaningless unless communicated well</li> </ul>	<p>knowledge embedded in the designs of nature?</p> <p>4. How do engineers communicate their designs?</p> <p>5. What makes a team function well?</p> <p>6. How do makers actively assure safety when using shop tools?</p>
<b>Transfer:</b>	<b>Freeman Wide Essential Questions:</b>
<ul style="list-style-type: none"> <li>• Effective collaboration is an essential element in most fields of work</li> <li>• The engineering design process is applicable to many problem-solving situations</li> <li>• Successful execution of a design requires care and quality, regardless of the field</li> <li>• Failing is a constructive part of design</li> </ul>	<p><u>Identity</u></p> <p>How does the design of a natural or made object affect me?</p> <p>What about me informs my design work?</p> <p>What is my role in the work group, and how does my makeup impact the way I collaborate?</p>

<b>Students will know....</b>	<b>Students will be able to...</b>
<ul style="list-style-type: none"> <li>• The safety procedures for the hand tools in the SLA shop</li> <li>• The parts of each tool and their use</li> <li>• Manufacturing processes available on each tool</li> <li>• The components of an engineering drawing</li> </ul>	<ul style="list-style-type: none"> <li>• Identify the requirements and constraints of a proposed design or problem</li> <li>• Brainstorm in a team effectively</li> <li>• Create a simple engineering drawing from a physical model</li> <li>• Design and build prototypes of designs that test essential elements</li> </ul>

## Stage 2 - Assessment

Transfer Tasks	Other Evidence
<p><b>Transfer tasks:</b></p> <ul style="list-style-type: none"> <li>• Deep observation and reflection on a chosen object's form</li> <li>• Creation and documentation of a popsicle stick bridge</li> <li>• Design and construction of a balloon car along with engineering documentation and analysis</li> </ul> <p><b>Evaluative Criteria</b></p> <ul style="list-style-type: none"> <li>• Care and accuracy of observations and sketches</li> <li>• Accuracy and standards compliance of final engineering drawing</li> <li>• Quality and completeness of the bridge along with load scoring</li> <li>• Quality and completeness of the balloon car</li> </ul>	<p><b>Other evidence:</b></p> <ul style="list-style-type: none"> <li>• Daily Spark Plug warm-ups</li> <li>• Engineering drawings of 3D printed parts</li> <li>• Safety exam</li> <li>• Engineering notebook</li> <li>• Contribution and leadership in the class</li> </ul> <p><b>Evaluative Criteria:</b></p> <ul style="list-style-type: none"> <li>• Responses in written and verbal form to formative assessments in the form of spark plugs and other in-class activities</li> <li>• Demonstration of engagement through active and accurate note taking</li> <li>• Ongoing scoring of in-class participation and leadership</li> </ul>

## Link to Freeman Core Values

Core Value	Link to Unit
<b>Inquiry</b> <i>How will this unit help students generate their own questions?</i>	Many days start with 'spark plug' warm-ups. Students will begin each challenge by asking what the goals, requirements and constraints of the project are
<b>Research</b> <i>When and how will students search for information in this unit?</i>	Students will research: The history of bridge building and how engineers have used various designs to meet differing requirements and constraints
<b>Collaboration</b> <i>When will students be working together in this unit?</i>	Collaborative brainstorming is a key focus of this course. Students will work through most challenges in teams. Final documentation will be individual.
<b>Presentation</b> <i>How will students be presenting their work and to whom?</i>	Students will present their results in the form of engineering drawings and related documentation. Engineering notebooks serve to record their activities for future communication.
<b>Reflection</b> <i>When will students be able to look back at their work and learning?</i>	Multiple reflections are built into the various projects and challenges.

## Daily Learning Plan

For Q1/Q2 2017, there are:

Mon/Thur class: Q1: 17, Q2:17 class days

Tues/Fri class: Q1: 18, Q2:19 class days

Therefore, **target 32 days** for this half-year class, roughly **16 days/Q**

Leaves for unscheduled downtime, testing, etc.

## Formal assessments in blue

### 00- Welcome to Engineering - 1 day

- Introductions
- Identity Design activity
- Notebook setup
- Designs You Like activity
- Course review
- CTE Engineering Program

### 01 - Engineering Design Process - 4 days

- FFF Introduction / Object observations (and grading) - 1 **Object Observation Sheet**
- Toothpick Challenge -1 **Toothpick Challenge Reflection**
- Engineering Design Process - Brainstorming - Victor Mouse Trap Challenge- 1

- Engineering Design Process / Mythbusters - 1

## **02 - Design and Fabrication - The Bridge Challenge - 11 days**

- Procedures and Safety - 1
  - Shop safety and related procedures
  - Machine certification process **Safety Exam**
- Shop Tools and Usage - 3 **Final Product Inspection**
- Bridge Build Challenge - 7
  - Introduction, research, prototyping, planning 3
  - Build Day - 1
  - Test Day - 1 Results of the Challenge (20 pts)
  - Analysis Day - 1
  - Reflection and work period - 1 **Reflection**

## ***END OF Q1***

## **03 - Design and Fabrication - The Balloon Car Challenge - 15 days**

- Engineering Drawings - 3 **Engineering Drawings**
- Balloon Car Challenge and Analysis - 12
  - 1 - Intro and Physics
  - 1 - Brainstorming and Research, Preliminary design
  - 5 - Design, Draw and Fab
  - 1 - Race Day
  - 2 - Analysis
  - 2 - Reflection and Final Report Workdays **Final Engineering Report**

## **04 - Final Day Engineering - 1**

- Final day discussions

## ***END OF Q2***

## **GRADING 2017/18**

Standardize on the same %'s for CC/Beeber and across quarters

100 pts

20 classiness

30 Notebook

50 Assignments



## Appendix M

### Kim's Everyday Math Curriculum

#### Everyday Math Curriculum

##### *Unit 1 (Quarter 1)*

#### **Word Bank:**

#### **Materials:**

- IXL Computer Log in
- Rulers
- Measuring Cups & Baking Supplies
- Sewing Machine and Materials for Pillow Making (fabric, cotton filler, needle and thread)

#### **Overview:**

\*Participants will review different forms of measurement, specifically;

\*Lining up a ruler correctly **and protractor?**

\*Measuring to the nearest inch, 1/2 inch, 1/4 inch

\*Measuring ingredients in a measuring cup, precisely and accurately

\*Combining Measurements (as needed) by **adding and subtracting fractions with unlike denominators (this will take a while for many students)**

\*Participants will apply these skills via work-like scenarios;

\*Baking: Banana Bread, Apple Pie Etc.

\*Sewing: Pillow Making, Designing a Pencil Skirt, etc. - Students will correctly follow instructions and measurements

\*Building: A Coffee Table, Bird House, etc.- Students will correctly follow instructions and measurements

#### **Rubric Milestones:**

**\*Participants will complete the following Units on IXL:**

1. **N.1** Measure using an inch ruler
2. **L.3** Add and subtract fractions with like denominators
3. **L.4** Add and subtract fractions with like denominators: word problems
4. **L.6** Add fractions with unlike denominators using models
5. **L.9** Subtract fractions with unlike denominators using models
6. **L.11** Add and subtract fractions with unlike denominators: word problems
7. **R.2** Convert between percents, fractions, and decimals
8. **U.3** Add and subtract decimals: word problems
- 9.

**\*All Participants will take part in the baking challenge via groups of four**

**\*Students will individually choose from the Sewing or Building Challenge**

**\*They will research a list of things that they are interested in creating**

**\*They will select a design that includes instructions and measurements  
and design the item of their choice.**

#### **Evaluation:**

**\*Formative Diagnostic**

**\*Completion/ Mastery via IXL**

**\*Baking Challenge Rubric**

**\*Design/Building Challenge Rubric**

**\*Summative Diagnostic**

#### **What will Canvas look like?**

**\*Formative Diagnostic scores, broken down per skill (i.e. 1, 2, 3, 4, 5 on measuring to the nearest inch, adding fractions with unlike denominators, etc.)**

**\*Summative Diagnostic scores, broken down per skill**

**\*Daily Participation Rating**

\*Each IXL skill listed (65% for 25% completion, 75% for 50% completion, 85% for 75% completion, 95% for 85% completion)

\*Baking Challenge Rubric

\*Design/Building Challenge Rubric

Other ideas that we may want to incorporate throughout Unit 1:

- Giving the correct medicine dosage (as a nurse)
- Adding and subtracting decimals, recognizing their fraction equivalences
- As a class, when modeling how to measure throughout the building process, design/build something that someone with a physical disability gain better access (i.e. an extender for silverware)



## Financial Literacy

### *Unit 2 (Quarter 2)*

#### **Word Bank:**

#### **Materials:**

- IXL Computer Log in

#### **Standards:**

### **Money**

#### **Level G**

1. S.1Add and subtract money amounts
2. S.2Add and subtract money: word problems
3. S.3Multiply money amounts: word problems
4. S.4Divide money amounts: word problems
5. S.5Price lists
6. S.6Unit prices
7. S.7Sale prices

#### **Level H**

### **Money**

1. U.1Find the number of each type of coin
2. U.2Add and subtract money amounts
3. U.3Add and subtract money amounts: word problems
4. U.4Multiply money by whole numbers and decimals
5. U.5Multiply money: word problems
6. U.6Divide money amounts
7. U.7Divide money amounts: word problems

### **Consumer math**

1. M.1Add, subtract, multiply, and divide money amounts: word problems (yes)
2. M.2Price lists (yes)
3. M.5Unit prices: find the total price (yes)
4. M.6Percent of a number: tax, discount, and more (yes)
5. M.7Find the percent: tax, discount, and more
6. M.8Sale prices: find the original price
7. M.9Multi-step problems with percents
8. M.10Estimate tips
9. M.11Simple interest
10. M.12Compound interest
- 8.

## Consumer math

### Level I

1. V.1Which is the better coupon?
2. V.2Unit prices
3. V.3Unit prices with fractions and decimals
4. V.4Unit prices with customary unit conversions
5. V.5Sale prices
6. V.6Sale prices: find the original price
7. V.7Percents - calculate tax, tip, mark-up, and more
8. V.8Simple interest

\*Designing a business...planning for a sale of your company's products....making the books to show your profit versus cost...

\*Or placing your money into savings...calculating the interest

\*Developing a budget???

**Overview:**

\*Participants will learn how to write checks and balance a check book (+/-)

\*Students will practice balancing a budget for a month

**Rubric Milestones:**

\*Participants will complete the following Units on IXL:

\*As a class, we will create a board game for students at the local elementary school, teaching them how to balance a checkbook

\*Given a make-believe budget with a set of mandatory clues and some optional clues, students will try to stay out of the "red" (sample clue... "you own a dog walking company, you receive a paycheck of \$2000, five times per month, which you have to split with two other business partners").

**Financial Literacy:**

-Balancing a checkbook

- positive and negative numbers

-Students create a board game that teaches younger students how to. A lance a checkbook

-Students will create a budget and given expenses, will show what their budget will look like over the course of a week or month (include \_\_,+,\*,\)... I.e. U receive a paycheck of \$2000 5 times per month, you have to split this with two business partners, etc. (give them word problems to take thru the budget... have them explain what operations they used for each step and why?)

-Learning about credit cards, understanding apr, interest rates, understanding ur credit score, and what it means to invest? Should we bring in speakers? Learning the vocabulary...I.e. Maintains ur account minimum

**Evaluation:**

\*Formative Diagnostic

\*Completion/ Mastery via IXL

\*

\*Summative Diagnostic

**What will Canvas look like? *(This is where I majorly need your help Karen!!!!)***

\*Formative Diagnostic scores, broken down per skill (i.e. 1, 2, 3, 4, 5 on measuring to the nearest inch, adding fractions with unlike denominators, etc.)

\*Summative Diagnostic scores, broken down per skill

\*Daily Participation Rating

\*Each IXL skill listed (65% for 25% completion, 75% for 50% completion, 85% for 75% completion, 95% for 85% completion)

\*Rubric for Balancing a Budget Project

-(Including Plan a Dream Prom)

-Operations combined with word problems...

-create a life size word problems quilt complete with algorithms for solving... donate to Gompers Elementary School

-Create other math toys for elementary age students (I.e. Wooden fraction puzzles) (I.e. Shapes cut into thirds, each labeled  $\frac{1}{3}$ ) then create some puzzles with pieces that have unlike denominators... make same size so we can show how they can be interchanged

### Everyday Math Curriculum

#### Financial Literacy

#### *Unit 3 (Quarter 3)*

#### **Word Bank:**

#### **Materials:**

- IXL Computer Log in

#### **Topics:**

- Averaging Yearly Pay based on checks per month
  - What's your salary for the year? How much do you get per month?
- Banking Terms
  - deposits, withdrawals
  - interest
  - writing a check
- Credit Cards
- Charts (pie, bar, etc.) → Excel
  - reinforcing fractions/division
- Loans
  - Interest (compound, etc.)
- <http://playspent.org/>

- [financeintheclassroom.org/student/activities.shtml](http://financeintheclassroom.org/student/activities.shtml)

### **Overview:**

- \*Participants will learn how to write checks and balance a checkbook (+/-)
- \*Students will practice balancing a budget for a month
- \*Students will understand certain banking terms

### **Project Ideas:**

Creating a budget for a family of 4

-Students will create a budget and given expenses, will show what their budget will look like over the course of a week or month (include  $-, +, *, \div$ )... I.e. You receive a paycheck of \$2000 5 times per month, you have to split this with two business partners, etc. (give them word problems to take thru the budget... have them explain what operations they used for each step and why?)

-Learning about credit cards, understanding apr, interest rates, understanding ur credit score, and what it means to invest? Should we bring in speakers? Learning the vocabulary...I.e. Maintains ur account minimum

### **Evaluation:**

- \*Formative Diagnostic
- \*Completion/ Mastery via IXL
- \*Summative Diagnostic

**Standards:**

- \*Multiplying Fractions by Whole Numbers
- \*Multiplying % by Whole Numbers
- \*Determining interest (simple &/or compound)
- \*Interpreting graphs (circle, bar, line graphs)
- \*Finding the average of a set of data
- \*Adding and Subtracting Positive and Negative Integers
- \*Solving Long Division Problems

**QUARTER 3: PROJECT COMPONENTS**

<p><b>Transportation:</b></p> <p>Research the monthly cost of leasing a car, buying a car, or taking public transportation (Hint- don't forget to include monthly gas prices, consider buying a used car)</p> <p>(*Route: From Your House to School)</p>	<p>*Create a bar graph to compare the monthly costs of each transportation option</p>
<p><b>Housing:</b> Research the house that you'd like to live in, do you want to rent or buy the house (use a website such as zillow to determine the monthly cost)</p> <p>(should they compare to options, so they can have a back up plan if they go over budget)</p>	<p>*Explain why this is where you'd like to live</p>
<p><b>Career:</b></p> <p>Research your career of interest, find out what the average annual salary is</p>	<p>*Given the yearly salary, use long division to determine your monthly salary</p>
<p><b>Schooling:</b></p> <p>Research the type of schooling that you need for your career, choose a school of</p>	<p>*Given the yearly cost of schooling, determine how much it will cost you per month (if you are paying out of pocket)</p>

<p>interest and research the yearly cost of attending</p> <p>(should they compare two options so they have a back up plan?)</p> <p>*Given the following loan where interest starts to accrue on the day you graduate... (choose a sample loan/interest rate)</p>	<p>without</p> <p>*Compare the cost of paying off your loan within in one year versus five years</p>
<p><b>FOOD:</b> Choose a grocery store online. Fill up your shopping cart with the items that you'd like to purchase for the week (take a screenshot of your cart)...multiply that by four to determine your monthly food cost</p>	
<p><b>PIE CHART:</b> Add up your total monthly budget, create a pie chart to show what percentage of money you spend on each component of your budget</p>	<p>Rent, Transportation, Food, School Loans</p>
<p><b>Using a check register....</b>write your monthly salary at the top.... now start deducting the cost of each component on the pie chart</p>	<p>*Use subtraction to withdraw from the total</p>
<p>Reflect: Will you be under budget or over budget? If you are over budget, what costs would you consider getting rid of? What options would you consider switching to?</p>	



## What is Credit?

### *Unit 4 (Quarter 4)*

#### **Word Bank:**

#### **Materials:**

#### **Topics:**

- What is credit?
- Why is it important to understand credit?
- How do I earn or raise my credit score?
- What are the different credit cards you can apply for?

#### **Overview:**

\*Students will read about good vs. bad credit and what affects credit

\*Students will research different types of credit cards

\*Students will understand important credit terms (minimum, APR, credit limit, grace period)

#### **Project Ideas:**

Creating a children's book about Credit

-Learning about credit cards, understanding apr, interest rates, understanding your credit score...

#### **Evaluation:**

\*Formative Diagnostic

\* Classwork Assignments

\*Summative Diagnostic

**Standards:**

\*Adding and Subtraction Fractions with Unlike Denominators

\*Multiplying Fractions

\*Dividing Fractions

\*Reducing Fractions

\*Mixed Numbers and Improper Fractions

\*Solving Algebraic equations that involve fractions

\*Writing Algebraic Equations